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DENTAL SURGERY.

DENTAL SURGERY:

INCLUDING SPECIAL ANATOMY AND PATHOLOGY.

A MANUAL
FOR STUDENTS AND PRACTITIONERS.

BY

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FOURTH EDITION.

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PREFACE TO THE FOURTH EDITION.

In the Preface to the Third Edition it was stated that the more limited original design had been extended, in the hope that the book might fulfil the requirements of a complete Manual of Dental Pathology and Surgery. The aim had been to supply all the information needed by the surgeon or practitioner of medicine, and to provide a solid foundation of knowledge for students intending to devote themselves to the practice of Dental Surgery.

The proper theme of the work had been closely adhered to, purely surgical topics being entered upon no further than seemed necessary to make clear questions relating to the pathology, diagnosis, and treatment of Diseases of the Teeth.

To this design the Editors, in preparing a Fourth Edition, have striven to conform, whilst endeavouring to bring the work up to the level of the science and practice of the day.

The Editors are indebted to Mr. Hopewell Smith for numerous valuable physiological drawings.

The pages thoughout have been carefully revised by Mr. Henry Sewill.

It has been thought well not to encumber the book with a great number of illustrations of instruments. All the instruments referred to are figured in the Catalogues issued by Messrs. Ash & Company, of Broad Street, Golden Square; the Dental Manufacturing Company, of Lexington Street, Golden Square; and the S. S. White Dental Manufacturing Company, of Philadelphia, U.S.A.

9A, CAVENDISH SQUARE,

April, 1901.

ERRATA.

PAGE 96. Ninth line from top, for *on dentition* read *of dentition.*

,, 174. In consequence of an error, undiscovered until the sheet had passed through the press, fig. 114 has been printed upside down.

,, 240. Second line of footnote, for *Odotological* read *Odontological.*

,, 267. Add the following footnote referring to paragraph one of the page. *See Appendix C. Antisepticism in Dental Surgery.*

,, 447. Second line of chapter heading, for *Glositis* read *Glossitis.*

,, 461. Fourth line from bottom, for *erosition* read *erosion.*

,, 561. Third line from top, for *fig. 248* read *fig. 249.*

CONTENTS.

DENTAL SURGERY:

INCLUDING SPECIAL ANATOMY & PATHOLOGY.

ANATOMY AND HISTOLOGY OF THE TEETH.

HUMAN TEETH are structures of bony character, implanted in the alveoli along the margins of the jaws for the purpose of triturating the food preparatory to its passage into the stomach. Two sets of teeth are developed during life; the first, the temporary, deciduous or milk teeth, ten in each jaw, and the second or permanent teeth, sixteen in each jaw.

The teeth are divided into classes according to their function and external configuration, but they have all certain characters in common. Every tooth consists ot *a crown*, the portion which appears beyond the gum, *a root* or roots imbedded in the jaw, and *a neck*, the portion which unites the crown and root, and is surrounded by the free edge of the gum.

The surfaces of the teeth are distinguished by appropriate names. That towards the lips is called the external labial or buccal; that towards the tongue the lingual or internal. The contiguous surfaces are best distinguished by the terms first used by Sir J. Tomes, namely, mesial for that nearest the middle line of the mouth, distal for that furthest away.

The permanent set is made up of four incisors formed for cutting, two canines for cutting and tearing, and four bicuspids and six molars for grinding the food.

The upper incisors have chisel-shaped crowns, the front surface convex, the back concave. Viewed laterally the crown is wedge-shaped, the base of the wedge being at the gum, the apex at the cutting edge. This configuration gives origin to the V-shaped spaces between the necks of contiguous teeth. The cutting edge is horizontal, its distal angle being rounded, its mesial acute. Before becoming worn by mastication the edge is marked by three small tubercles, which give it a serrated appearance. The root is single, conical, and slightly compressed laterally. The central are about one-third larger than the lateral incisors. A point of some small importance is the shape of the basal ridge or cingulum. The enamel ends in a curved line with the convexity towards the gum on the labial and lingual surfaces ; on the median and distal surfaces it is V-shaped, the apex of the triangle being away from the gum. It is well to remember this fact when shaping the cervical edge of a cavity preparatory to filling it.

The lower incisors are similar in shape to the upper, but they are smaller, the root is more flattened at the sides, being deep from before backwards; both angles of the cutting edge are acute, and unlike the upper teeth the lower central are less in size than the lateral incisors.

The upper canines, or eye teeth, are stronger than the incisors, to which they bear a general resemblance. The crown is convex anteriorly, and less convex, or somewhat flattened, posteriorly, with a ridge running down to the apex of the cusp. The crown may be compared to that of an incisor with the angles bevelled off, and terminating in a sharp central cusp. The posterior ridge, joining the cingulum above, sometimes forms a cusp. A similar ridge or cusp occasionally is found on lateral and central incisors and frequently

caries begins in the angle so produced. The upper canines have a single root which is stronger and longer than any other of the set. It is conical in shape and slightly more flattened laterally than that of an incisor.

The lower canines are smaller than the corresponding upper teeth, the cusp is more obtuse, and the posterior surface more concave, the root more flattened at the sides.

The upper bicuspids viewed from the front, bear a close resemblance to the canines, than which, however, they are smaller. The crown springs vertically from the neck, its labial and lingual aspects being convex, its mesial and distal surfaces somewhat flattened; and its diameter across the jaw is thus the longer. The masticating surface is divided by a deep antero-posterior groove into two cusps, of which the inner is the smaller, it is, in fact, the increased size of the cingulum which produces this cusp. The root is conical, and more compressed laterally than that of either the incisor or canine. It is deeply grooved and often bifid; and the cleft, commonly in the first bicuspid, rarely in the second, divides the root throughout the greater part of its length. The inner cusp of the second bicuspid is relatively larger than the outer, making the labial and lingual surfaces nearly equal.

The lower bicuspids in general characters resemble the upper, but are smaller. The internal cusp is less well marked, and the root is much compressed laterally, but very rarely bifid.

The molars have crowns of a cube-like form, the labial and lingual aspect rounded, the mesial and distal flattened. The grinding surface is divided by grooves into tubercles or cusps. The neck is rounded and well defined. The first molars of either jaw are the largest, the wisdom teeth the smallest of the series.

The masticating surface of an upper molar has four cusps, one at each angle. Of these the antero-internal is the largest and is connected with the postero-internal by an oblique ridge of enamel. Thus, it is possible to tell when extracted to which side an upper molar tooth belonged (supposing the cusps to be intact). In the third molar or wisdom tooth the internal cusps are blended into one mass. The first and second upper molars have three conical roots, two external spreading apart upwards towards the antrum, and one, the smallest, directed towards the palate. The latter is occasionally bifid. The root of the wisdom tooth is, as a rule, single, forming an irregular conical mass, which is often either deeply grooved or shows traces of subdivision into three roots. The crowns of the lower molars are a little larger than those of the upper jaw, and they are surmounted by five cusps, one at each angle, and the fifth between the two posterior cusps rather nearer the labial surface. Owing to the manner in which the upper teeth meet the lower, the inner cusps of the lower molars are higher (less worn down) than the outer, while the reverse is the case in the upper—*i.e.*, the inner cusps become always most worn down by use in mastication. The first and second lower molars have each two roots, one anterior and one posterior. In rare cases a third root is present. The roots are broad, compressed, and grooved on the surfaces turned towards each other, and they have an inclination slightly backwards in the jaw. The root of the lower wisdom tooth, like that of the upper, is often connate, but occasionally it is bifid or divided into distinct fangs.

The entire set of teeth in each jaw are arranged in an elliptical curve, the incisors, canines and bicuspids forming an almost perfect semicircle, the molars and

bicuspids continuing the lines backwards. The lower teeth are placed vertically in front and looking somewhat inwards at the sides and behind, whilst the corresponding upper teeth have an inclination forwards in front and outwards behind, so that the upper teeth slightly overhang the lower. In consequence of this arrangement and the difference in size between the teeth of the two jaws, each upper tooth on closure of the jaws impinges partly on the corresponding lower tooth and partly on the tooth next following; but the upper dental arch being larger than the lower, and the upper molars being smaller than those of the lower jaw, the upper wisdom teeth do not extend backwards beyond the range of the lower teeth.

The teeth are fixed in position by implantation of their roots in the alveoli of the jaws, the bone, lined with periosteum, investing and accurately fitting them and providing a separate socket for each root. This form of articulation has been termed *gomphosis*, from its resemblance to the impaction of a nail driven into wood.

The annexed diagram from Wedl* (fig. 1), shows at one view the form and character of a normal set of teeth, the direction and arrangement of the roots within the bone, and the relation of the upper and lower sets to each other when closed.

The temporary teeth (fig. 2) resemble the permanent set, but are considerably smaller. There are no bicuspids in this set. It is made up of four incisors, two canines, and four molars. The first upper molar is smaller than the second, and its crown has three cusps, two external, one internal. The second upper molar has four cusps. The first lower molar is smaller than the second, and has four cusps. The

* Pathologie der Zähne, 1870.

second lower molar has five cusps, three external, two internal. The roots of the temporary set are similar to those of the corresponding permanent teeth. The fangs of the molars are, however, more divergent from the neck of the tooth, and are hollowed on their inner aspect to afford space for the crypts of the developing bicuspids situated beneath them. In the

FIG. 1.

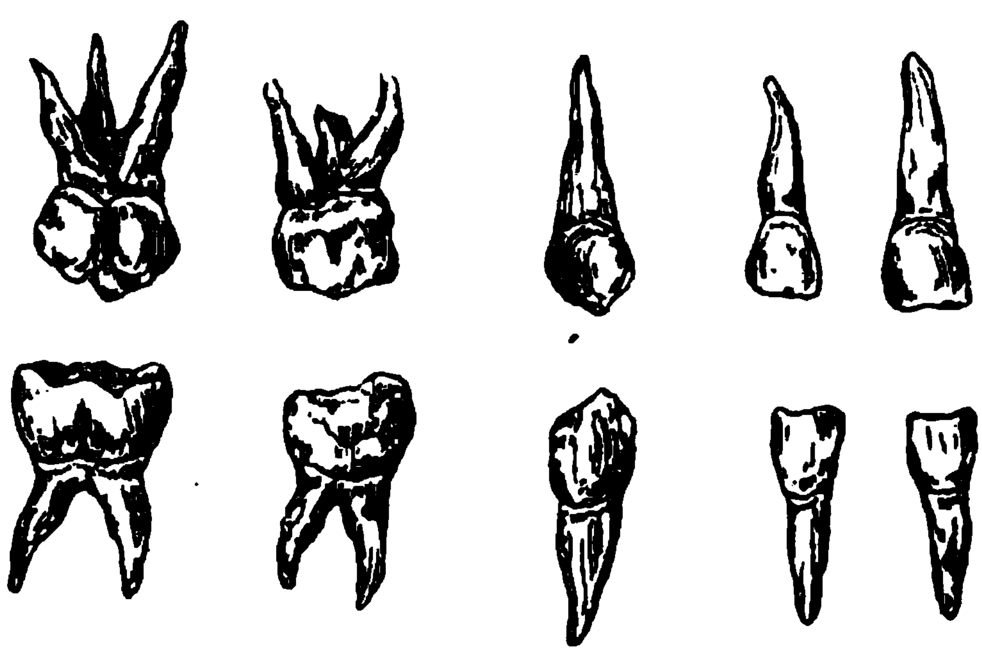
temporary set the enamel ends in an abrupt ridge at the neck of the tooth beneath the free edge of the gum.

The dental tissues.—On section (figs. 3 and 4), a tooth is seen to be composed of three tissues, distinct in structure, but intimately united with each other: enamel which covers the crown, cement which coats the roots, and dentine which forms the great bulk of the organ. When the teeth first make their appearance the enamel is covered by a thin layer of peculiar tissue, the cuticula dentis or Nasmyth's membrane, which,

however, becomes soon worn off by mastication. In the centre of the tooth is the pulp cavity, a chamber similar in shape to the external outline of the tooth, and containing a vascular and nervous structure, the dental pulp. The vessels and nerves of the pulp enter through foramina in the apices of the roots.

Enamel forms a cap or layer adapted to the surface of the dentine. It attains its greatest thickness on the cutting edges and summits of the masticating

FIG. 2

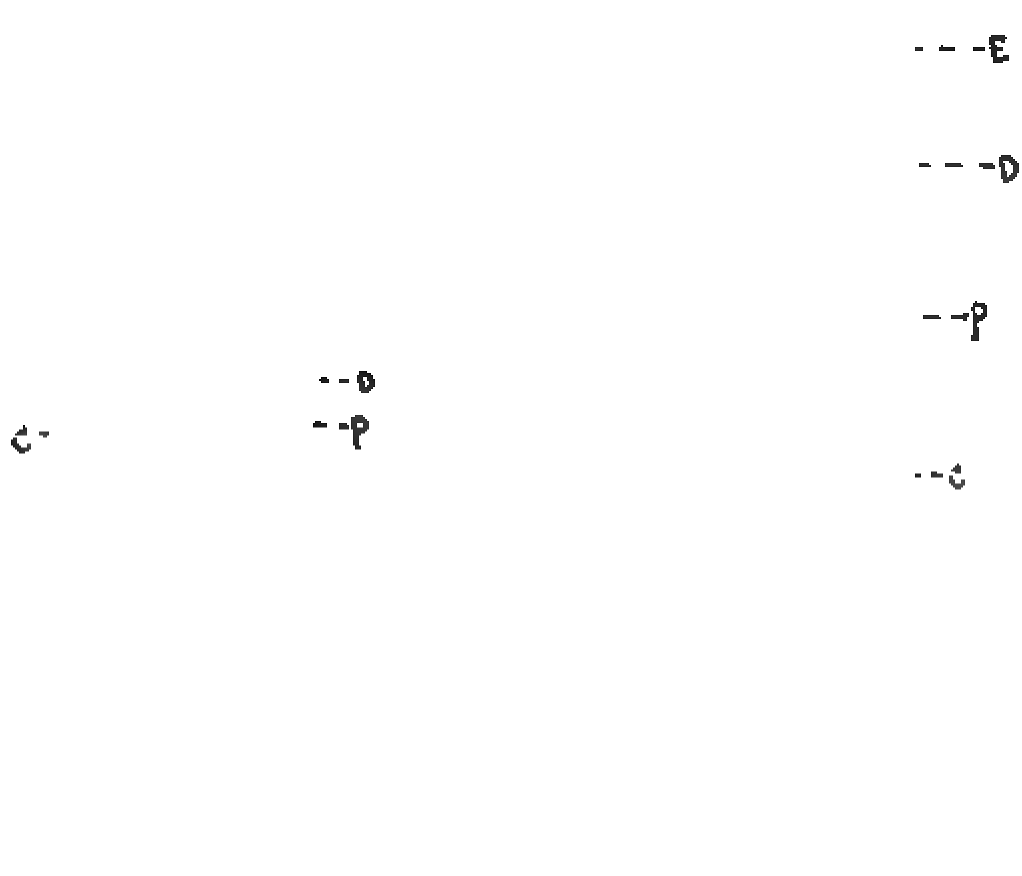


Upper and lower temporary teeth of right side

surface of the teeth, whence gradually decreasing, it slopes towards the neck and terminates beneath the free edge of the gum, where it is slightly overlapped by the cement. It is an extremely hard translucent substance, either of a yellowish or of a bluish white colour. It is the hardest tissue of the body, ranking in density with limpid quartz, and emitting a spark when struck with steel. It contains ninety per cent. of calcium phosphate, with a trace of fluorine, and four to five per cent. of calcium carbonate, the remainder being made up of traces of magnesium phosphate and other

salts. The tissue holds about three per cent. of water, which is not driven off at a temperature under 300° F. The presence of this percentage of moisture probably led earlier investigators to believe in the constant presence of that amount of organic matter in enamel. Enamel is

FIGS. 3 and 4.



Diagrams of vertical sections of upper canine and molar tooth.

E. Enamel. D. Dentine.
C. Cement. P. Pulp chamber.

entirely soluble in acids, leaving in some specimens the smallest trace of organic matter, due to imperfect calcification. It is devoid of sensibility.

Examined microscopically (figs. 5, 6, 7, 8) enamel is found to consist of solid fibres or prisms mostly

Fig 5.

Section of Enamel. × 75 showing the general course of the prisms. The point of junction with Dentine is seen below.

Photo-micrograph by Mr Charters White.

Fig. 6.

Section of Enamel, stained with chloride of gold. × 650. The prisms are here seen under high magnifying power.

Section by Mr. A. Underwood

Fig. 7.

Diagram of Enamel in transverse section showing form of prisms.

Fig. 8.

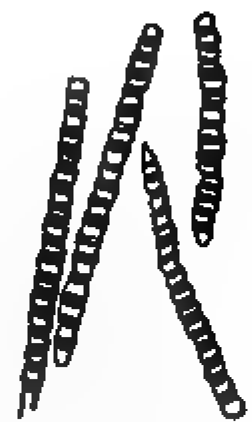


Diagram of Enamel Prisms separated and viewed laterally.

hexagonal, but some nearly square, others nearly circular lying parallel side by side.

Dr. Leon Williams* has demonstrated a differentiated substance lying between the prisms and uniting them; this he designates "cement substance." It is visible as transparent lines between the prisms under high magnifying power, × 2,000. It can also be demonstrated in sections which have been exposed to the action of weak acid. The substance of the enamel rods offers much greater resistance to acids than the interprismatic cement substance. The amount of cement substance in enamel varies considerably, not only in different specimens but also in different parts of the same specimen. Sometimes the enamel rods are in actual contact; sometimes separated by spaces filled with cement substance, equal to a fourth or fifth of the diameter of the rods.

Dr. Leon Williams is among the latest investigators who have confirmed the fact that mature enamel contains virtually no organic matter whatever. Therefore in describing the cement substance between the prisms he evidently does not suggest an organic structure, but merely a portion of the tissue essentially the same in its nature as the bulk, differing only in respect of density or some other molecular peculiarity.

Enamel fibres spring from depressions on the surface of the dentine, and radiating outwards in an undulating course towards the exterior of the tooth, their direction varies between vertical at the masticating surface and horizontal at the sides. Most of the fibres extend through the whole thickness of the tissue; and, although they cannot be demonstrated, there must exist, probably, shorter supplemental fibres, to fill up the intervals which would otherwise occur in consequence of the

* Dental Cosmos, February, 1896, *et seq.*

divergence of the longer prisms in their outward course. The diameter of the prisms is about $\frac{1}{5500}$ of an inch. They are mostly marked at short regular intervals by transverse striæ, so that each fibre resembles a sheath containing a line of granular masses, but this condition is not very visible in young and in dense well-formed tissue. The prisms (figs. 6 and 8), also show at intervals slight bulgings or varicosities. They perhaps constitute the remaining trace or expression of the soft cell elements in which the tissue existed before calcification. The apparent decussation of the prisms, a peculiar pattern exhibited by enamel in section beneath the microscope, is not real. The tissue is made up of many layers, the fibres in each layer being parallel, but the direction pursued by fibres of different layers varying considerably. The appearance of decussation is visible only under a high magnifying power, in a thin section which is made up of several layers of prisms, and which is of course transparent. Hence the crossing of fibres, which actually lie on different planes, gives rise to the apparent free decussation of prisms lying on the same plane.

For the purpose of pathological study it may be taken as a fact demonstrated beyond controversy that enamel is a calcareous mass, well-nigh homogeneous, absolutely devoid of active physiological elements, and containing not more than a barely recognisable trace of organic matter. Where more than such a trace is recognisable it is due to imperfect calcification, and forms an innate structural abnormality. A contrary opinion formerly held by some observers formed the foundation for speculations with regard to the etiology and pathology of dental caries. These are discussed in later chapters.

Dentine or ivory forms the great bulk of the tooth,

and encloses the central cavity. It is a yellowish-white elastic tissue, presenting a finely fibrous fracture, and intermediate in hardness between enamel and dense bone, which latter it resembles somewhat in its general aspect and chemical characteristics. It contains twenty-eight per cent. of animal and seventy-two of earthy matter. Fresh dentine contains ten per cent. of free water. Treated with acids the earthy constituents are dissolved, and there remains a material called dentinal cartilage, which retains the form of the tooth, and which is precisely similar to the animal basis of ordinary

FIG. 9.

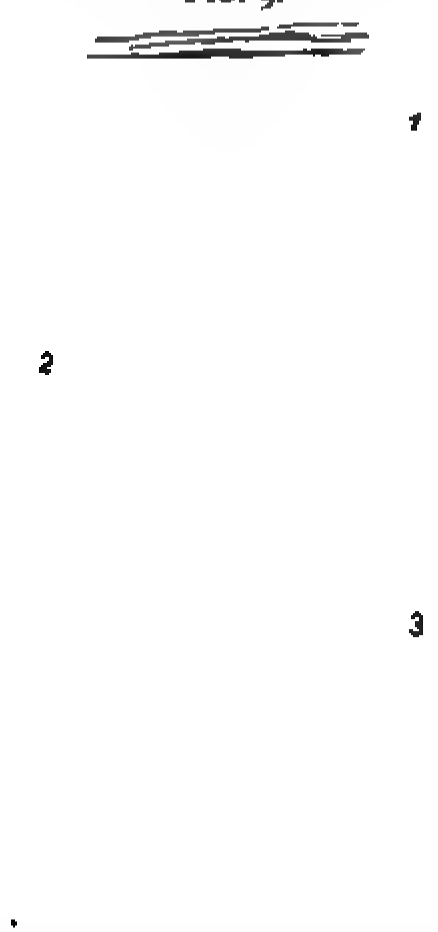


Diagram of transverse section of root of a canine tooth.
1. Cement. 2. Granular layer. 3. Dentine.

bone tissue. The basis of dentine and of bone tissue is called collagen, a body of close resemblance to gelatine. The seventy-two per cent. of earthy constituents are made up of 64 parts of calcium phosphate, 5 of calcium carbonate, and 3 of magnesium phosphate and other salts, with a trace of fluorine. It will perhaps assist the reader's memory to consider these chemical compositions side by side in a tabulated form :—

TABLE OF CHEMICAL COMPOSITIONS OF DENTINE, ENAMEL, AND BONE.

	Enamel	Dentine.	Cement-Bone.
Water and Organic matter	3·50	28·00	33·30
Calcium phosphate and fluoride	90·00	64·00	53·04
Calcium carbonate... ...	4·50	5·50	11·30
Magnesium phosphate ...	1·50	1·00	1·16
Other salts (chiefly sodium)	·50	1·50	1·20
	100	100	100

Examined microscopically (figs. 9, 10, 11, 12, 13), dentine is found to consist of innumerable minute tubes having apparently distinct walls, and running close together through an intermediate substance—the intertubular substance or matrix. Commencing by open orifices on the walls of the pulp cavity, the tubes radiate outwards in an undulating course towards the periphery of the dentine, which they do not reach, each one becoming smaller and breaking up into branches which freely anastomose beneath the surface of the dentine. The tubes are more numerous in the crown than in the root.

FIG. 10.

Vertical Section of Dentine.
under low power, × 175.
Photo-micrograph by Mr. Charters White.

FIG. 11

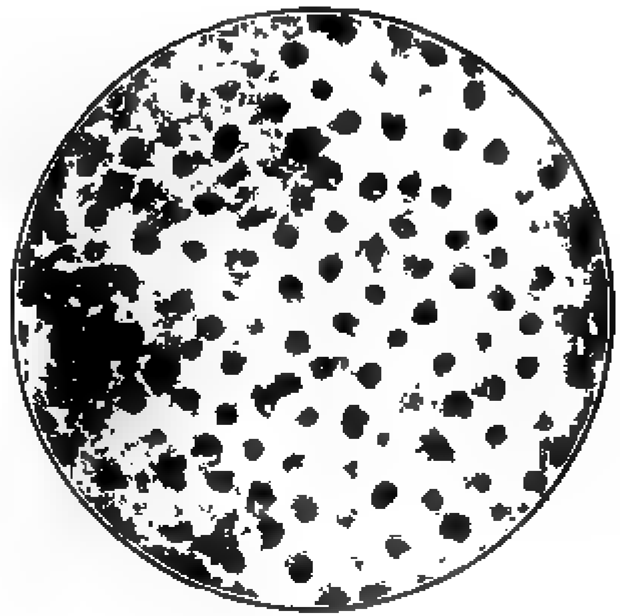
Vertical Section of Dentine, stained with carmine, showing tubes, under high power, × 650. Above, on the left is the point of junction with enamel into which tissue a few tubes are seen to penetrate.

Section by Mr. A. Underwood.

Fig. 12.

Fig. 14.

Fig. 13.



Transverse Section of Dentine, under high power, × 650, showing orifices of tubes.

Transverse Section of Dentine. × 50.

Photo-micrograph by Mr. Charters White.

Section of Cement. × 75, showing lacunæ and canaliculi. The point of junction with Dentine is shown below.

Photo-micrograph by Mr. Charters White.

C

In the upper part of the crown the tubes have a vertical direction; towards the sides they become oblique, then horizontal, finally incline downwards towards the point of the root. The dentinal tubes in their course make two curves upon themselves; the longer, called primary curves, are not unlike the italic letter *f*; these are best marked in the crown. The secondary curves are more numerous, smaller, and are best marked in the root. They are of the nature of elongated spirals. Each tube as a rule extends throughout the whole thickness of the tissue. Their diameter is about $\frac{1}{4500}$ of an inch, being larger at the inner ends than at a distance from the pulp cavity. They are also more close together near the pulp, less matrix being between them there. The distance between adjacent tubes is about two or three times their width. The tubes and their branches are occupied by soft fibrils which anastomose; and it can be shown, by staining with chloride of gold, that they form a continuous network. These fibrils seem to spring from the central pulp, and they appear to be continuous with elongated processes of the odontoblasts, the special cells of the pulp. The inner surfaces of the tubes surrounding the fibrils are called the dentinal sheaths or sheaths of Neumann. These sheaths are probably in an intermediate condition between the fully calcified matrix and the wholly uncalcified fibril. It has been stated that the only difference between these three tissues, matrix, tube, and fibril, is that they represent different degrees of calcification of the same tissue. That there must, however, be some difference is obvious from the fact that the tubes are often discernible in interglobular spaces where no calcification whatever has taken place. The sheaths can be demonstrated most clearly after removal of the fibres by maceration, and they remain

as a white fibrous felt even after boiling in strong muriatic acid, or in caustic alkalies. Vascular canals proceeding from the pulp (common in the teeth of some mammalia) sometimes occur as rare abnormalities in human dentine. They are usually minute.

The intertubular substance or matrix is translucent and without any visible structure. It contains the greater part of the earthy constituents of the dentine.

The dentinal tubes terminate in the crown by fine processes (fig. 11) which either anastomose or become extremely minute, and are lost beneath the enamel, into which tissue, however, a few may penetrate. In the root (figs. 9 and 14) they end beneath the cement, by opening into the irregular spaces of the granular layer, and frequently passing through to anastomose with the contents of the canaliculi.

The granular layer of the root (figs. 9 and 14), which exists between the dentine and cement, may be said to constitute the line of transition where these tissues blend. The layer is made up of granules or minute globules, and contains numerous spaces apparently due to imperfect coalescence of these elements. Into these spaces (as above mentioned) the dentinal tubes open, and the spaces are again connected with the lacunæ of the cement by fine canaliculi.

Dentine is endowed with a considerable amount of sensibility, due to the soft fibrils which permeate its tubes, and which, as we have seen, directly emanate from the pulp. The sensibility of healthy dentine varies very much in the teeth of different individuals and in different parts of the same tooth. It is always more marked immediately beneath the enamel than deeper, until the pulp chamber is approached. The sensibility disappears when death of the pulp takes place.

Owing to their minuteness it has hitherto been

impossible to demonstrate the exact structure of the dentinal fibrils, although the attempt has been made to prove that they are really extremely fine filaments proceeding from the nerves of the pulp. It has however been conclusively shown that whatever their structure, to them the sensibility of dentine is due. Mr. Charles Tomes has pointed to some facts which establish this view, and prove that the sensibility is not, as has been suggested, due merely to transmission of vibrations through an inert conductor to the pulp. For instance, the peripheral sensibility of dentine can be allayed by applications which do not affect the pulp; and it often happens that a sensitive layer of dentine overlays a less sensitive portion placed deeper and closer to the pulp. These circumstances can only be explained by the supposition that the seat of sensibility lies within the tissue.

The demonstrated facts with regard to the physiology of dentine which must be borne in mind when considering possible pathological phenomena in this tissue, may be summed up as follows:—Dentine consists of a virtually homogeneous calcareous matrix, devoid of vascular, cellular or other active elements. The matrix invests a basis or frame-work of tough dense fibrous substance, also entirely devoid of active physiological elements. The tissue is endowed with sensibility through the medium of extremely minute fibrils, which proceeding from the pulp radiate in tubes throughout its substance.

Cement (figs. 9 and 14) forms a thin layer, which, commencing at the neck, where it slightly overlaps the enamel, gradually increases towards the apex of the root. It is a true bone structure, having the same chemical and microscopical characters as that tissue. Existing only in a thin layer in man, cement is, however, destitute of Haversian canals. It contains, as a rule, canaliculi throughout, and lacunæ at its thicker parts, enclosing

during life protoplasmic contents which form by anastomosis a continuous network. Canaliculi and lacunæ may be wanting where the tissue is extremely thin. In the latter case it presents on section a perfectly homogeneous appearance.

The cement is invested with periosteum which is directly continuous with the periosteum of the jaw. It unites the cement to the socket, and consists of a single layer, not two as formerly supposed. The fibres of this periosteum run obliquely upwards from the cement to the socket. It is a delicate connective-tissue membrane, containing abundance of vessels and nerves, derived from those of the submucous tissue, from those which supply the pulp, and from those of the contiguous alveolar wall.

Nasmyth's membrane (fig. 15) is an extremely thin tissue, covering the enamel. It exists undamaged only on young teeth which have not been long used in mastication. It resists the action of the strongest mineral acids, but softens when boiled in caustic potash. Until recently the majority of authorities were agreed that Nasmyth's membrane was a thin layer of cement modified in structure, and homologous with the thick coronal cement found on the teeth of herbivorous animals Mr. Paul* has shown that these views are no longer tenable, and that Nasmyth's membrane consists of two layers, derived from the external epithelium of the "enamel organ," described in a later section. The outer of these two layers is composed of flat epithelial cells, containing large nuclei. Beneath these cells and on the enamel lies an inner thin structureless layer or matrix, which, on being stripped from the enamel, shows hexagonal impressions or markings derived from the free ends of the enamel prisms.

* Dental Record, 1896.

Coronal cement of well-marked structure, containing encapsuled lacunæ and canaliculi, occasionally occurs in human teeth. When such a layer does not exist it may be often found that sulci or fissures of the enamel such as commonly exist between the cusps on the masticating surface of molars are filled with a bone-like tissue, apparently continuous with Nasmyth's membrane.

FIG. 15.

B

A

C

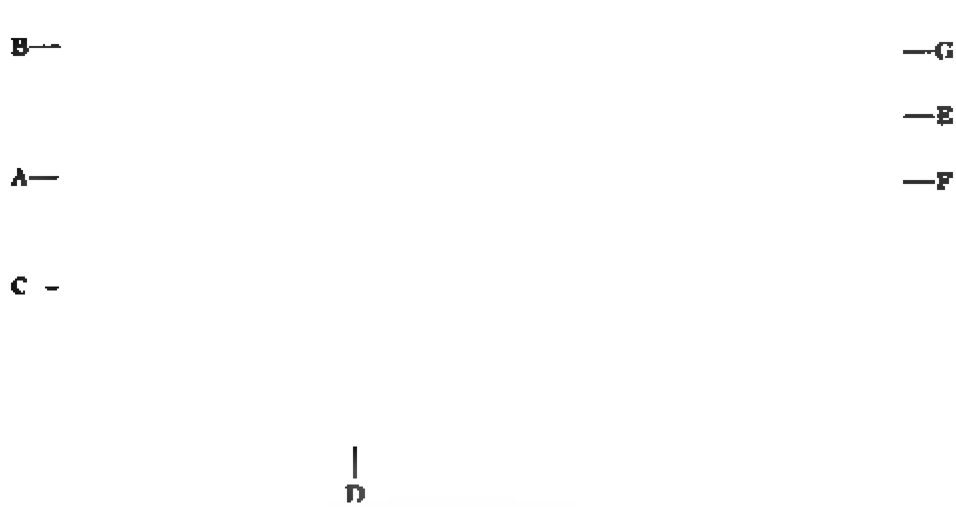
Nasmyth's Membrane, highly magnified.
From a drawing by Mr. Hopewell Smith.

A. Epithelial cells of outer layer.
B. Matrix or inner layer.
C. Impressions of Enamel Prisms on inner transparent layer.

The dental pulp (fig. 16) which occupies the central cavity consists of the remains of the original papilla from which the dentine was developed. It is composed of fine fibrous connective tissue, containing numerous cells, and is well supplied with blood vessels and nerves, which

enter through small foramina in the apices of the roots. Mr. Charles Tomes describes the pulp as being made up of "a mucoid gelatinous matrix" containing cells in abundance, and but little connective tissue. The outermost cells of the pulp—that is, those that immediately line the dentine—are of a special form, larger and more regular than the others, and are known as the *membrana eboris* or odontoblast layer. Each odontoblast is oval

FIG. 16.



The structure of the Dental Pulp. From Adult Canine. × 200
From a section prepared by Mr. Hopewell Smith.

A. Dentine.
B. Pulp tissue.
C. Odontoblasts.
D. Basal layer of Weil.
E. Artery.
F. Vein.
G. Nerve fasciculus.

or pear-shaped, with a well marked nucleus at the end farthest from the dentine, and has two processes. These are distinguished as the outer or peripheral and inner or basal processes. Of these processes the outer seem to

penetrate the canals in the dentine to become the fibrils. Some observers believe the fibrils are more probably nerve endings derived from the pulp beneath the odontoblast layer through which they pass. Boll has especially supported the latter view. He was the first to point out the great number of non-medullated nerves in the superficial part of the pulp tissue, and to show that they ascend between the odontoblasts towards the tubuli into which he believed they entered as fibrils. The whole subject of the distribution and termination of the nerves in the pulp must, however, be taken as being at present under consideration. No visible communication between the nerves of the pulp and the odontoblast cells has yet been demonstrated.

Below the odontoblast layer, most marked in the crown and absent near the growing end of tooth, lies the basal layer of Weil (fig. 16, D). It is a somewhat transparent zone, and was originally described as consisting of connective tissue fibres communicating with the processes of the odontoblasts. Doubt has, however, been thrown upon this observation, and save for its translucency, the zone is probably not differentiated from pulp tissue.

Fig. 16 from a preparation by Mr. Hopewell Smith, illustrates the histology of the pulp. The drawing represents a transverse section from an adult canine decalcified and stained with rubine. The odontoblasts are seen in close apposition to the dentine. The so-called basal layer of Weil is seen below; while in the pulp tissue may be noticed several blood vessels and a nerve fasciculus.

Lymphatics have not yet been demonstrated in the pulp.

As age advances, gradual calcification of the pulp takes place, until at last it is reduced to a few fibrous filaments, with the remains of vessels and nerves. Mr. C. Tomes describes a process of degeneration which

occurs in the remains of the pulp in advanced age, by which it becomes reduced to a shrivelled unvascular insensitive mass. Mr. Hopewell Smith describes* and figures† this condition which represents the natural termination of the life-history of senile pulps. This he has named "Fibroid degeneration." Sections exhibit the absolute disappearance of all cells, nuclei, blood-vessels and nerve-bundles, nothing remaining but a firm, dense network of fine, connective tissue fibres.

The tissue resulting from calcification of the pulp is called secondary dentine. Calcification may commence near the external layer of odontoblasts, and the new formed tissue in most instances coalesces with the previously formed dentine, but the tubes of the two may or may not be continuous. In other cases secondary dentine is deposited in isolated nodules scattered through the pulp. These nodules sometimes unite and form larger masses, which again may become attached to the walls of the pulp cavity. The masses of secondary dentine are occasionally traversed by canals containing blood-vessels, and surrounded by concentric lamellæ, like the Haversian canals of bone.

Newly-formed dentine resulting from pathological action has been named by Mr. Hopewell Smith‡ adventitious dentine, and must be clearly distinguished from the foregoing. It will be found fully described in the chapter dealing with diseases of the pulp.

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* Journal Brit. Dent. Assoc., 1892.

† Dental Microscopy, 2nd Edition, 1899.

‡ Dental Microscopy, 2nd Edition, 1899.

DEVELOPMENT OF THE TEETH.

THE first trace of dental development in man is visible to the naked eye as early as the seventh week of intra-uterine life, when the embryo is not more than one inch and a quarter in length. This trace consists of a smooth oval ridge extending along the whole length of the rudimentary alveolar border (*a*, fig. 17). Section of this ridge

FIG. 17.

a

After Legros and Magitot.*

Section of the incisive region of the lower jaw of an embryo sheep. This preparation corresponds with the phase of dental evolution existing in the human embryo at about the seventh week.

a. Epithelial ridge which extends the whole length of the maxillary arch, but of which the section only is here visible. From this ridge the primitive tooth band will be given off later.

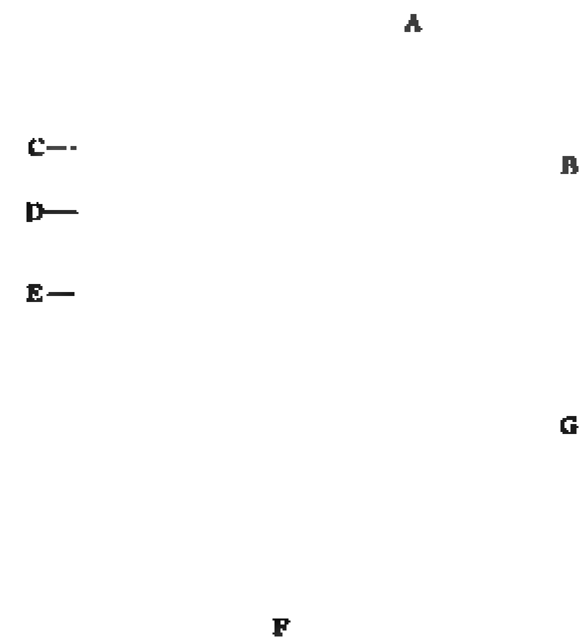
shows it to be a continuous vertical band composed of a thick layer of epithelial cells, and it is, in fact, a

* Origine du Follicule Dentaire. Journal de l'Anatomie, 1873

prolongation of the epithelial layer of the mouth which has sunk into the embryonic tissue of the jaw.

Before the end of the eighth week there has become developed, at about the middle of the buried or deep surface of the ridge, a projection or lamina (*d*, fig. 18), which,

FIG. 18.



Section through lower jaw of fœtal pig. This preparation corresponds with the phase of dental evolution existing in the human embryo at about the eighth week.

From a preparation by Mr. Hopewell Smith.

A. Oral epithelium.
B. Deeper layer of epithelium.
C. Deepest layer of epithelium (Rete Malpighii).
D. Primary inflection of enamel organ (primitive tooth band).
E. Internal epithelium of enamel organ.
F. Bone of jaw.
G. Sub-mucous tissue.

like the layer from which it is derived, extends the whole length of the maxillary border. This is called the primitive tooth band. Its shape is a little flattened from above

downwards, with its extremity rounded and curved in the form of a crook. It is composed externally of columnar cells of the deep or Malpighian layer of the mucous

FIG. 19.

A

B

C —D

—G

F—

E

I—

H

Section through lower jaw of fœtal pig. This preparation corresponds with the phase of dental evolution existing in the human embryo at about the tenth week.

From a preparation by Mr. Hopewell Smith.

A. Oral epithelium.
B. Deeper layer of epithelium.
C. Deepest layer of epithelium (Rete Malpighii).
D. Neck of enamel organ.
E. Internal epithelium of enamel organ.
F. External epithelium of enamel organ.
G. Stellate reticulum of enamel organ.
H. Commencing formation of dental sac.
I. Dentine germ.*

membrane, internally of squamous cells. Within a few more days there can be demonstrated along the border of the epithelial lamina in each jaw a series of ten small club-shaped enlargements (E fig. 18). These enlargements

or buds are the rudimentary enamel organs of the temporary teeth, and they are situated at intervals corresponding to the position of the future teeth. The shape

FIG. 20.

A

B

—D

C

—J

E —

—G

F—

H I

Section through lower jaw of fœtal pig. This preparation corresponds with the phase of dental evolution existing in the human embryo at about the thirteenth week.

From a preparation by Mr. Hopewell Smith.

A. Oral epithelium.
B. Deeper layers of epithelium.
C. Rete Malpighii.
D. Neck of enamel organ (remains of primitive tooth band).
E. Internal epithelium of enamel organ.
F. External epithelium of enamel organ.
G. Stellate reticulum.
J. Permanent tooth germ.
H. Commencing formation of dental sac.
I. Bone of jaw.

of each bud is at first like the finger of a glove pushed into the submucous tissue; then the end grows, becoming larger than the neck. It is flask-shaped, with its central or lowest point directly over the future dentine organ. The dentine germ is commonly called the dentine papilla, and though this is a very convenient term, it must be remembered that there is never, in reality, any free dental papilla. The apex of the future papilla arrests the further descent of the central part of the enamel organ, but the sides of the organ continue to descend round the papilla, enveloping it in a double layer, and assuming the shape that an india-rubber ball takes if a finger be pushed against it. The form of the enamel organ appears to be independent of the presence of the dentine forming germ, its peculiar shape apparently being due to independent growth.

The annexed drawing (fig. 21) represents diagrammatically three stages of the descent of the enamel organ

FIG. 21.

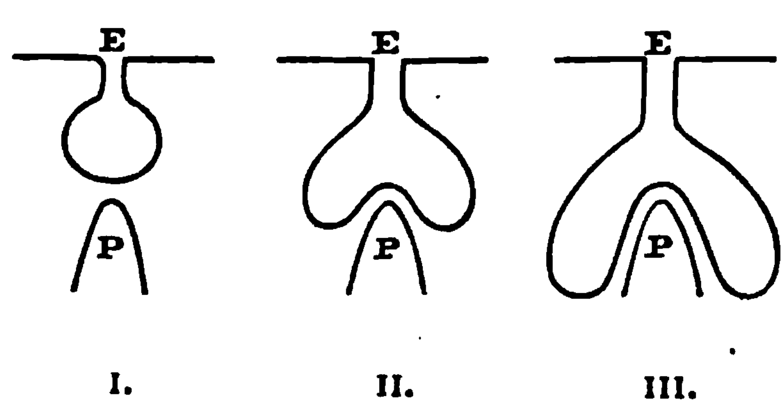


Diagram of descent of the enamel organ upon the dentine germ.
E. Enamel organ.
P. Dentine papilla.

on to the dentine papilla. It must, however, be borne in mind that this is supposed to be only a section of the object, and also that the papilla is not visibly differentiated so early.

The buds (figs. 18, 19, 20)—the rudimentary enamel organs of the temporary teeth—are composed of the same epithelial elements as make up the lamina, and they are destined by subsequent deposit of calcareous matter to become the external or enamel layer of the crown of the tooth. They remain for some time united to the lamina by a narrow portion in the form of a neck, which grows longer as the enamel organ increases in size. The enamel organs soon begin to assume the form of the crowns of the future teeth, but at first their shape is not well defined, and resembles a cap with the concavity directed towards the depths of the jaw.

By this time (the ninth week) the first appearance of the dentinal pulp may be detected. This germ (1, fig. 19) eventually becomes converted by calcification into the dentine or ivory forming the bulk of the tooth. Its elements first manifest themselves in the depths of the jaw independently of the enamel organ, but directly contiguous to its deeper surface. The pulp at first consists of a small papilla composed of nucleated cells, and penetrated by a vascular loop, and it is, in fact, at this stage merely a special division of the mucous tissue unusually rich in vessels and cells. Later, when it has assumed more definite shape, nerve filaments can be traced into it. It grows until it impinges upon the enamel organ, which becomes moulded upon it like a cap, whilst the papilla gradually assumes the form of the crown of the future tooth. Thus, for the incisors it becomes conical and for the molars develops outgrowths corresponding to the cusps of these teeth.

By the beginning of the fourth month each rudimentary temporary tooth has become enveloped in a distinct closed sac composed of sub-epithelial connective tissue. An opaque fibrous outgrowth springs from each side of the base of the pulp, and grows towards the summit of

the tooth, where it unites with that of the opposite side, and so forms the dental sac. This sac begins to appear as soon as the dentinal pulp is slightly advanced in development. By this time the connection between the enamel organ and the epithelial process from which it emanated has become severed, owing to absorption of the uniting neck or band of epithelium at the surface of the sac, and this absorption slowly progresses until the whole of the process disappears, leaving the sac completely isolated.

The origin of the permanent set, consisting of sixteen teeth in each jaw, has now to be described. The enamel organs of the ten teeth which replace the temporary set—namely, the incisors, canines and bicuspids—originate from a bud for each tooth, given off from a continuation of the original primitive tooth band (J, fig. 20).

The enamel organ of the first permanent molar is a continuation of the extremity of the same epithelial band that gave origin to the temporary teeth. From the epithelial process of this enamel organ a bud springs for the second permanent molar in exactly the same manner as the permanent successors of the temporary set were evolved from the epithelial processes of that set. In a precisely similar fashion the enamel organ of the third molar, or wisdom tooth, arises from the epithelial process of the second molar.

These sixteen germs in each jaw constitute the first traces of the permanent teeth, and they each pass through the same phases of development as we have seen undergone by the germs of the temporary set; these phases being the appearance of the dentinal pulp, its junction with the enamel organ, and their enclosure in a sac. The only further difference to be noted between the development of the permanent and deciduous teeth is in the time which particular teeth take to pass through the

successive stages of evolution. For example, the temporary teeth are usually all cut by the third year, whilst the first permanent molar, although its germ appears at the fifteenth week of fœtal life, is not erupted until the sixth year. Similar remarks apply to the rest of the permanent set; but it will suffice now to give the dates of the phases of their development so far as above described. The enamel organs of the incisors, canines and bicuspids make their appearance about the sixteenth week of intra-uterine life; those of the first permanent molars about the fifteenth week; those of the second molars about the third month after birth; and those of the wisdom teeth can be demonstrated towards the third year. The dentinal pulps of the ten first-mentioned teeth appear at the twenty-fourth week of fœtal life; those of the first molars at the seventeenth week; those of the second molars about the sixth month after birth; and those of the wisdom teeth towards the end of the fifth year. The complete closure of the sacs of these teeth is accomplished in the order in which they have been above mentioned at the following dates—ninth month, twentieth week, first year and sixth year.

The appearances and anatomical relations of the parts in the later stages of evolution of the teeth, are shown with exquisite clearness and exactitude in the illustrations, figs. 22, 23, 24, 25 and 26.

Histogenesis of Enamel and Dentine.—The histological changes which take place in the tooth germ by which its elements are gradually converted into the dental tissues, must be now more fully described.

With the progress in late years of practical microscopy, the more certain employment of high powers, and improvements in cutting and staining sections, it has become possible to follow and trace out with advancing minuteness histogenetic processes, such as calcification

FIG. 22.

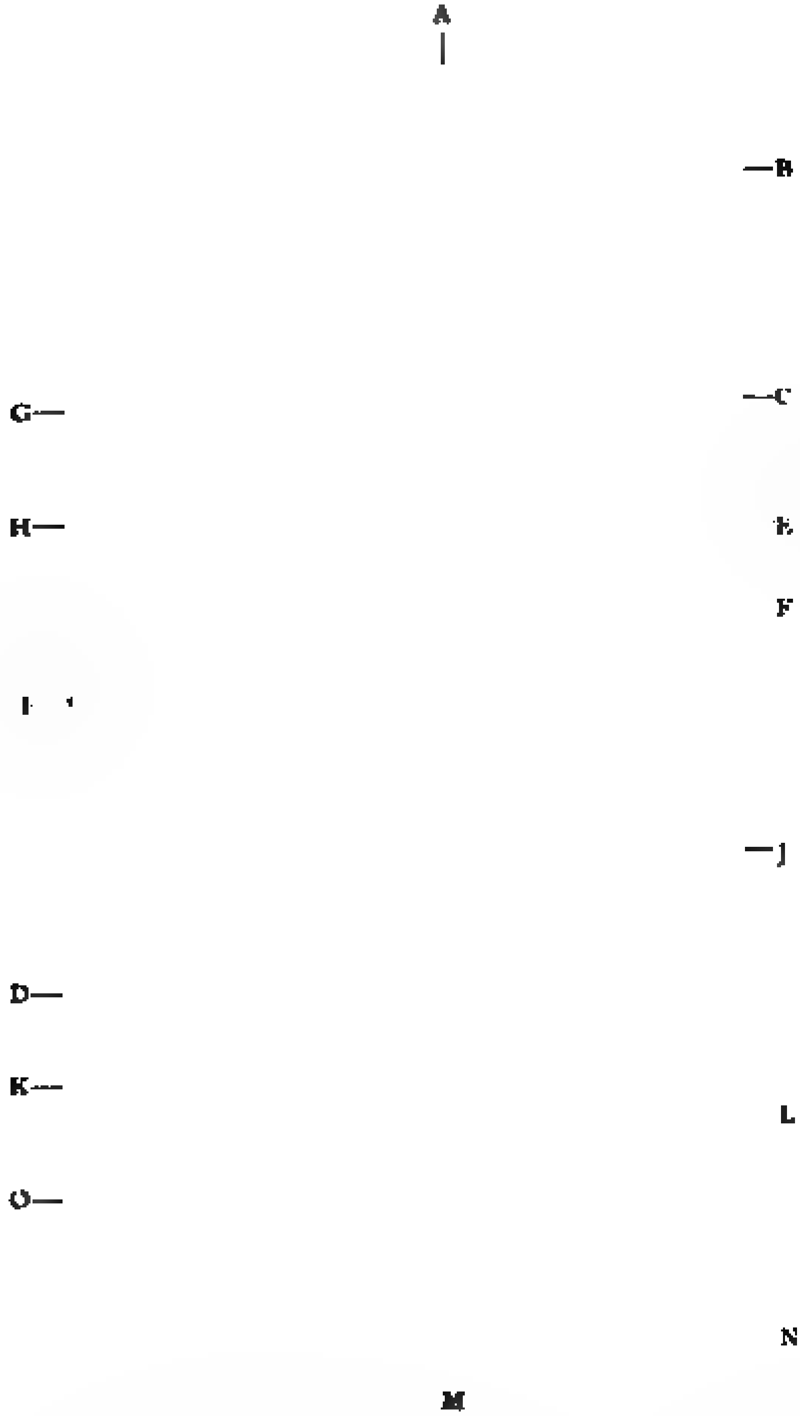
A— B— C— —D —G E— K— —J L— —M —N —V F— —O P— —X R— S— T— —Y

Section through the lower jaw of a fœtal pig. This preparation corresponds with the phase of dental evolution existing in the human embryo at about the fourth month.

From a preparation by Mr. Hopewell Smith.

A. Oral epithelium.
B. Deeper layer of epithelium.
C. Deepest layer of epithelium (Rete Malpighii).
D. Neck of enamel organ (primitive tooth band).
E. Internal epithelium of enamel organ and stratum intermedium.
F. External epithelium of enamel organ.
G. Stellate reticulum.
J. Permanent tooth germ.
K. Formed enamel.
L. Formed dentine.
M. Layer of odontoblasts.
N. Basal layer of Weil.
O. Commencing formation of dental pulp.
P. Epithelial sheath of Hertwig.
R. Artery.
S. Vein.
T. Nerve fasciculus.
V. Bone of jaw.
X. Muscular fibres.
Y. Periosteum of alveolus.

FIG. 23.



Section of lower jaw of human fœtus at about the fifth month. From a preparation by Mr. Hopewell Smith.

A. Oral epithelium.
B. Neck of tooth germ.
C. Permanent tooth germ.
D. Dental pulp.
E. Odontoblasts.
F. Dentine.
G. Enamel.
H. Ameloblasts and stratum intermedium.
I. Tooth sac.
J. Alveolar periosteum.
K. Stellate reticulum.
L. Muscle fibres of jaw.
M. Artery, vein, and nerve in transverse section.
N. Bone of jaw.
O. Epithelial sheath of Hertwig.

Fig. 24.

—A

—B

—C

—D

—E

—F

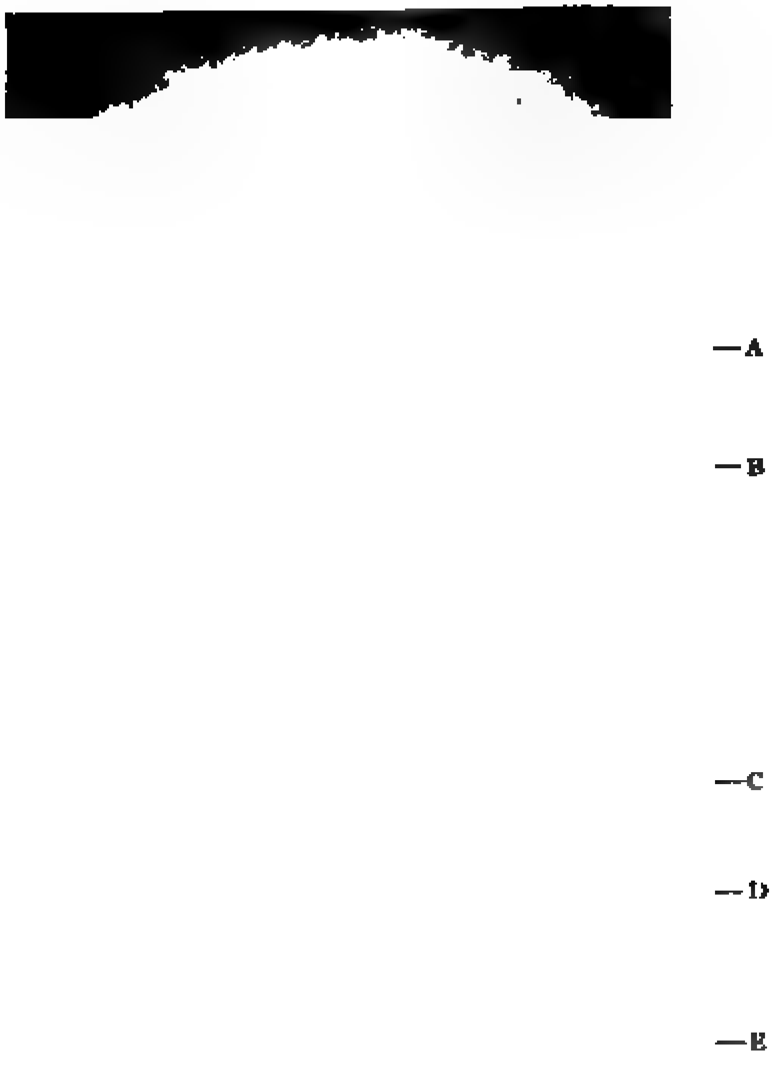
Section of Lower Jaw of Fœtal Kitten, with Temporary Tooth and permanent successor *in situ*. × 24 diameters.

This preparation corresponds with the phase of evolution in the most developed teeth in the human infant at about the third month after birth.

Photo-micrograph by Mr. Charters White.

A. Gum.
B. Enamel.
C. Dentine.
D. Dental pulp.
E. Permanent tooth enclosed in sac.
F. Jaw partly ossified: and section of inferior dental artery and nerve.

FIG. 25.



Section of Lower Jaw of Kitten, with Temporary Canine fully erupted and permanent successor *in situ* × 10.

This preparation displays the conditions immediately after complete eruption of a temporary tooth before absorption of the root has commenced.

Photo-micrograph by Mr. Charters White.

A. Deciduous canine.
B. Mucous membrane of gum.
C. Inferior maxilla cartilaginous; with islands of forming osseous tissue.
D. Permanent canine in its sac.
E. Inferior dental canal, and section of dental artery and nerve.

FIG. 26.

—A
—B
—C
—D
—E
F

Developing Permanent Tooth, shown in Fig. 23, more highly magnified. × 34 diameters.

Photo-micrograph by Mr. Charters White.

A. Dental sac.
B. Enamel organ.
C. Formed enamel.
D. Formed dentine.
E. Odontoblast layer
F. Dentinal pulp with traces of vessels.

of the dental tissues. These researches, whilst establishing the facts of most importance, have led to differences of opinion with regard to many minor points. These differences of opinion, as well indeed as the whole subject of dental histogenesis, have more of purely scientific interest than of practical bearing upon pathology. The structural characters of the completed tissues which are demonstrable beyond dispute determine the nature of pathological phenomena; and, as will be seen later, these phenomena are now fully understood. Further research into the histogenesis of enamel and dentine may, however, probably throw light upon the subject of inherent weaknesses and defects in the tissues, a subject, as will be seen in a later chapter, which has a very important bearing upon the etiology of caries.

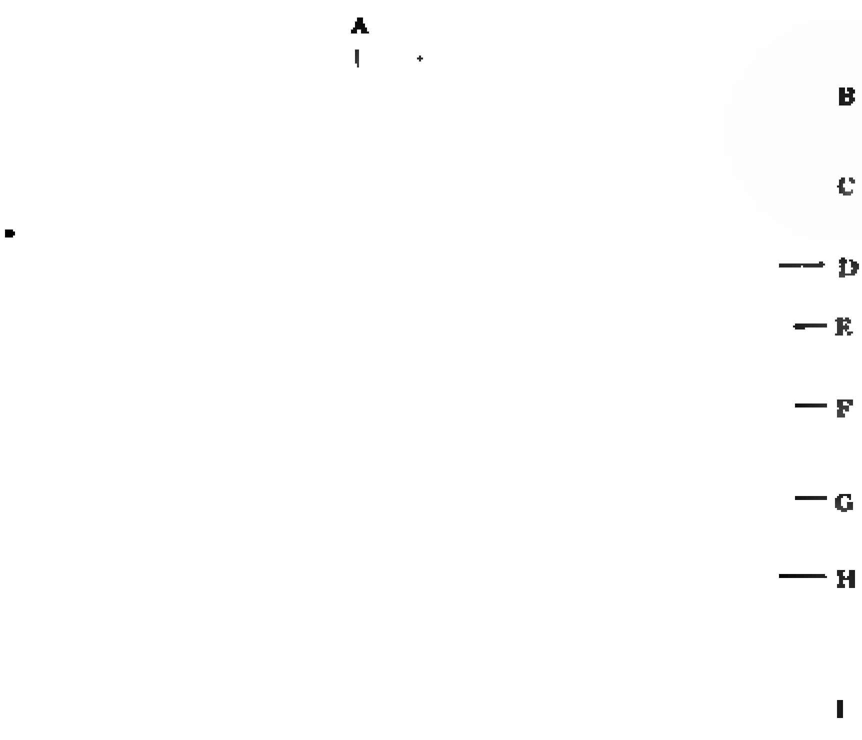
Calcification of Enamel.—It has been seen that the enamel organ (figs. 18 and 19) when first formed is composed entirely of columnar epithelial cells. It retains its epithelial nature throughout the process of calcification. This process begins at the surface of the dentine and progresses outwards. Prior to deposition of earthy matter the cells immediately in contact with the dentine increase greatly in length, and form six-sided prismatic bodies so arranged as to constitute a columnar epithelium, which, according to Waldeyer, is the most beautiful and regular found in any part of the body (figs. 27 and 28). This layer forms the internal epithelium of the enamel organ. The specialised cells are designated ameloblasts. On removal from the surface of developing enamel they are seen to have at their base, and in the direction of the forming enamel tapering processes, first described by Sir John Tomes, and known as "Tomes' processes." The layer of ameloblasts is continuous at the deepest part of the developing tooth with a layer of small cubical cells, which becomes

recurrent for a varying distance over itself and a part of the row of ameloblasts. This is known as the epithelial sheath of Hertwig—the physiologist who first described it (figs. 22 P and 23 O). It probably plays an important part in determining the direction and shape of the roots of the teeth. In course of time the sheath undergoes atrophy.

The cells of the external epithelium of the enamel organ are shorter and more cubical in form. The cells lying between the internal and external epithelium of the enamel organ undergo transformation during the formation of the tissue. At first small and round, they soon become stellate in form, united with each other by their processes. From the cells of this layer (called the *stratum intermedium*), in contact and united with the internal epithelium, it is not impossible that a continuous development of columnar enamel cells may proceed. Vascular papillæ, arising from the contiguous tissue of the dental sac, penetrate to a slight depth the external epithelium, and serve doubtless to provide nutriment to the developing tissue. But the presence of blood vessels within developing enamel is still a matter of controversy.

It has been just stated that the deposition of calcareous matter commences in the enamel organ at the surface of the dentine and proceeds outwards (figs. 27 and 28). The completed tissue results from the activity of the internal epithelium. But it is to be understood that the cells do not themselves calcify, and that calcification takes place in and around the Tomes' processes, the ameloblasts apparently being mainly concerned in the secretion of the calcific material. Calcification progresses from the periphery of each cell towards its centre, at the same time uniting together the contiguous columns. Prior to the completion of the enamel the external epithelium and remaining portion of the *stratum intermedium* undergo atrophy.

FIG. 27



Section of Developing Tooth of Dog. × 260.
From a preparation by Mr. A. Underwood.

- A. Outer layers of enamel cells.
- B. Stratum intermedium.
- C. Enamel cells.
- D. Formed but uncalcified enamel.
- E. Calcified enamel.
- F. Calcified dentine.
- G. Formed but uncalcified dentine.
- H. Odontoblasts.
- I. Pulp tissue.

FIG. 28.

A

B

C

D

E

Enamel portion of Fig. 27, more highly magnified. × 650, displaying the appearances visible in the enamel pulp during calcification.

A. Outer layer of enamel cells.
B. Stratum intermedium.
C. Enamel cells.
D. Formed but uncalcified enamel.
E. Calcified enamel.

F

The above description of enamel calcification includes the main salient facts on which agreement exists among authorities.*

The whole subject has more recently been investigated by Dr. Leon Williams.†

Dr. Leon Williams has striven to establish the correctness of his observations by the most elaborate and consecutive series of microscopical sections (reproduced by photography) hitherto published; and his conclusions, even if it be not possible to pronounce them final, deserve serious attention. The following is the briefest possible summary of Dr. Williams' views. He holds that formation of enamel is effected by the deposit of an albumen-like, calcific-bearing material in an organic stroma, reticulum or basis substance. The organic stroma or basis is the cytoplasm of the enamel-forming cell. The nuclei of the enamel-forming cells are situated at the ends furthest removed from the forming enamel. He believes that the layer of cells known as the *stratum intermedium* is chiefly concerned in the absorption and elaboration of the calcific material from the blood. This material is passed on to the ameloblasts. His reason for assigning this function to the cells of the *stratum intermedium* is to be found in the special arrangement which they present in the persistently growing teeth of rats, mice and other rodents. The cells of the *stratum intermedium* in the animals referred to are arranged in the form of glandular papilæ, surrounded by a freely anastomosing network of blood vessels. The formation of enamel begins by deposit of the calcific-bearing material in the end of the enamel cell lying next to the dentine.

* Köllicker, Huxley, Magitot, Tomes, Waldeyer.

† Transactions of Royal Society, 1895. Dental Cosmos, 1896. Journal of Royal Microscopical Society, 1897.

A globular mass just filling the lower end of the cell is somewhat rapidly formed, followed by a period of comparative inactivity, and this period is again succeeded by the formation of another globular mass which is deposited simultaneously on the top of the first by all the ameloblasts of the growing tooth. This process continues until completion of the formation of the enamel. During the whole of the period of the development of the tooth the enamel-forming cells or ameloblasts continue to grow outward or away from the dentine. As the cells continue to grow the cytoplasm of each cell becomes the basis-substance of the enamel rod. The basis-substance of each enamel rod is, therefore, the organic reticulum left behind by the continual outward growth of the enamel-forming cell. As is well known, the ameloblasts have no limiting membrane along their sides. The calcific substance is, therefore, not strictly confined to the organic reticulum of the cell. A small portion of it flows out and between the cells. This solidifies at the same time and along with that deposited in the organic network of the cell and constitutes the so-called cement-substance uniting the enamel rods. But the calcific-bearing material which is deposited within the cytoplasmic network, thus forming the body of the enamel rod, and that which is deposited between the rods are one and the same substance. There are, therefore, but two physiological products concerned in the building of enamel; the organic stroma which is the reticulum of the ameloblasts, and the albumen-like, calcific-bearing material which forms the cement substance.

Dr. Leon Williams believes that the result of the intermittent, rythmic action referred to above is the sectional markings observed in the formation of the enamel rods. This reaches its most marked phase in the formation of

the teeth of the rodents, noticeably those of the rat and squirrel families. In other forms of teeth, those of the marsupials, for instance, the deposit of the calcific material seems to go on regularly from start to finish. The result of this is that the sectional or cross markings of the enamel rods observed in the teeth of rodents and some other animals, including human teeth, are rarely, if ever, to be found in the enamel rods of marsupial teeth.

Dr. Leon Williams believes that the differences in the structure of completely developed enamel rods, as revealed under the highest magnifying power, are seen to correspond perfectly with the varieties of structure shown in the cytoplasm of the ameloblasts. In the final steps of calcification of enamel, by some process at present quite unknown to us, but which for the present may perhaps be compared for the sake of illustration to that of fossilization, the organic stroma in nearly all forms of mammalian enamel is completely solidified, so that scarcely a trace, if any, of its organic constituents remains. By very careful decalcification of marsupial enamel, however, a considerable substratum of organic material is left after the complete removal of the lime salts, and this substratum is seen to correspond perfectly in structure and general appearance with the original cytoplasm of the ameloblasts.

Calcification of Dentine.—Calcification of the dentinal pulp (figs. 27 and 29) begins before that of the enamel organ. The process by which the conversion is effected resembles in a manner the histological formation of bone. With the nature of this process the student will have already become acquainted by his reading in general physiology. The dentine is formed by the secretion of calcific material by specialized cells upon the fibrous basis of the pulp. The fibres in which calcification takes place earliest are arranged in a membrane directly beneath the

enamel organ. Calcification commences at the external surface and proceeds inwards, the central portion with the vessels and nerves remaining to constitute the persistent dental pulp or "nerve" of the tooth. The dentinal pulp (as already mentioned) at first consists of a special division of the rudimentary mucous tissue, rich in vessels and cells. By suitable staining reagents it can be demonstrated to be finely fibrillar, and it is in this fibrillar tissue that the dentine matrix is first discoverable. This tissue is in all probability of the nature of fine connective tissue. When the pulp has arrived at a certain stage of development the cells begin to be specially organised and arranged. This layer of cells constitutes the *membrana eboris*. The next stage in the direction of calcification is the appearance of large oval nuclei at short distances from each other amongst the surface layer of pulp cells.

Mr. Paul* is of opinion that the cells lying at the periphery of the dentinal pulp do not enter into the formation of the odontoblasts; that these cells have already "reached the climax of their development, their nuclei passing on to a resting stage . . . . whilst their fibres are increasing. Their function is not to become odontoblasts but to produce the fibrous basis in which the first layer of dentine is deposited." The basal part of the odontoblasts is finely granular; the cells have no membrane, and contain a large rounded nucleus. In the older works on dental anatomy, the odontoblasts are described as being each provided with numerous processes, uniting them with contiguous odontoblasts and with subjacent developing cells, but Mr. Paul has never been able to satisfy himself that the odontoblasts give off more than one process, namely, that which

* Transacs. Odontological Society, 1899.

FIG. 29.

Dentinal portion of Fig. 27, more highly magnified. × 650, displaying the appearances visible in the dentinal pulp during calcification.

A. Calcified dentine.
B. Formed but uncalcified dentine.
C. Odontoblasts.
D. Pulp tissue.

forms the dentinal fibril. He is inclined to the opinion that they do not give off either lateral or deep processes. Blood vessels ramify in the pulp matrix, and can be seen amongst the odontoblasts, and there is in this position always a layer of fibrillar tissue derived from the same matrix, as well as a layer of fibres enveloping the necks of the odontoblasts. The researches of Mr. Hopewell Smith* tend to show that the odontoblasts possess a peripheral and a basal process only, and that while dentinal matrix is being deposited on the surface of the pulp, they are connected with one another merely by a collar of semi-calcified material surrounding their dentinal extremities. Mr. Hopewell Smith holds that the odontoblasts are in effect organs which act as sensation receivers and transmitters, their peripheral processes forming the dentinal fibrils; and that the calcific constituents of the dentine are secreted by smaller cells named by him dentogenetic. In support of this view he adduces the frequent formation of secondary dentine in the centre of the pulp by means of these small cells. His microscopic sections apparently show these cellular elements at work in tissue production.

As calcification progresses the odontoblast layer or *membrana eboris* is constantly fed from the deeper layer of cells. The layer of matrix immediately around the fibrils probably becomes converted into the dentinal sheaths—the lining walls of the tubes. It is, however, held by some observers that the dentinal sheaths have no distinct existence, and can be demonstrated only after disintegration of the tissue by strong acid. It has not yet been ascertained whether the sheaths are calcified or not, since their structure cannot be examined except after maceration.

* Transacs. Odontological Society, 1894.

By the end of the seventeenth week of intra-uterine life a cap of enamel and dentine may be demonstrated on the pulps of all the temporary teeth (figs. 22 and 23). By the sixth month the first permanent molar has advanced to a similar stage of development. By the first month after birth the permanent incisors and canines are advanced to the same stage; and at the third year and twelfth year respectively, calcification has commenced in the second molars and wisdom teeth.

The entire crown of each tooth is represented in soft tissue before deposition of earthy salts commences, and as the tooth elongates by growth of the pulp from below successive portions undergo calcification to form the root.

Histogenesis of Cement and Nasmyth's membrane.—The development of cement has not been made out beyond dispute. It probably takes place in a matrix formed by the investing fibrous coat of the dental sac. A special cement pulp has not been demonstrated in man. Cement is, in fact, a thin layer of bone, and the process of its formation is in all probability similar to intra-membranous ossification of other bones.

The cuticula dentis (Nasmyth's membrane), is formed from the residuum of the pulp of the enamel after the completion of that tissue. It was formerly looked upon as merely a thin layer of modified osseous tissue continuous with the cement, having a similar origin, and homologous with the coronal cement found on the teeth of certain herbivorous animals—a view which as already explained has in late years been overthrown.

GROWTH OF THE JAWS.

FIRST AND SECOND DENTITION.

COMMENCING as early as the fifth week of fœtal life, ossification of the maxillary bones proceeds rapidly, and is well advanced at birth. The lateral halves both of the upper and lower jaws at this period are, however, still united in the median line by cartilage, and the growing alveoli of the temporary teeth are indicated by a deep trench, divided by incomplete bony plates into large crypts, in which the teeth lie enclosed by the dental sacs and submucous tissue. The temporary teeth are represented by their partly calcified crowns, the stage of development varying in the different teeth according to the period at which their eruption is destined to take place. Thus the crowns of the central incisors are nearly complete, whilst, as yet, the apices alone of the rudimentary crowns of the canines have become converted into a cap of calcified material.

During the first few months after birth, the development of the maxillæ is most active at the surface adjacent to the connecting cartilages and at the alveolar border. The alveoli increase in depth, and by the growth of their free margins of bone overhang and protect the contained teeth. A little later they become nearly closed.

The age at which eruption of the temporary teeth commences in different individuals varies somewhat, but

it is rarely earlier than the fifth, or later than the ninth month. Eruption of the teeth is a process of gradual elongation of the teeth on the one hand, and of simultaneous absorption of the superimposed tissues on the other. The absorption commences first in the overhanging margins and front walls of the alveoli, which gradually disappear until room is afforded for the free passage of the advancing tooth. The growth of the tooth keeps pace with this absorption, and the crown at length pressing against its membranous coverings these undergo atrophy, and, becoming by degrees thinner, and at last transparent, give way and disclose the advancing crown.

Disorders of Dentition.—It occasionally happens that the developmental processes included in the eruptive stage of dental evolution are not perfectly harmonious in their course, the advance of the tooth being more rapid than the disappearance of the enclosing bony and soft tissues. The tooth is thus mechanically held in position, and irritation is set up, which manifests itself by inflammation and induration of the gums, and even by reflex nervous disorders, and constitutional disturbance of various kinds. This explanation, which, it must be admitted, is very far from satisfactory, is perhaps the best that can be given of the occasional unquestionable connection between "teething" and infantile disorders; for although the connection seems taken as proved by most writers on infantile diseases, it is rare to find any attempt to trace the nervous phenomena to their source, and to explain the correlation between eruption of the teeth and the varieties of trivial and grave disorders, such as diarrhœa, skin affections and convulsions, commonly ascribed to this physiological process. That eruption of the teeth is a physiological not a pathological process, and need not, more than other similar processes of growth and

development, necessarily be attended with morbid phenomena, is, however, a fact which is commonly lost sight of. Most so-called "disorders of dentition" would be more correctly described as disorders occurring during the period of first dentition, and there can be no question that in a vast number of cases infantile diseases are ascribed to "teething" which have no relation whatever to the process of dentition, many of them being due to such causes as improper food and feeding. That a great part of the infantile maladies commonly set down to teething are due to other and preventible causes is proved by the fact that mortality among the infants of the poor is enormous, compared with that among the well-to-do and wealthy classes. The causation of the diseases leading to this mortality is complex, but it is safe to affirm that "teething" cannot be placed scientifically among the prime factors in their etiology. On the subject of the feeding of infants, a vast and deplorable amount of ignorance prevails among the poor; and even when they are aware of the importance of a milk diet during early infancy, they are often unable to obtain an unsophisticated supply of the necessary food. Damp, dark, and insanitary dwellings combined with uncleanliness form the sole cause, or the predisposing cause of more ill-health; and in these surroundings exanthematous and zymotic diseases assume almost as a rule a virulent character. Add to this that the mother may have been ill-fed and hard-worked during the child-bearing period, and enough has been suggested to account for the "disorders of dentition" among the poor. Whilst it is impossible to ascribe to the natural physiological process of tooth-eruption all the effects upon the general health so often set down to it among all classes of infants, there can be no doubt on the other hand that conditions of impaired

health and mal-nutrition during early infancy are enough in themselves to give rise to ill-development of the dental tissues. This subject is dealt with in its proper place on a later page under the heading "Hypoplastic Teeth."

It is, however, the opinion of physicians who have had the opportunity of watching large numbers of children, that even in perfectly healthy and well-managed infants a certain amount of local irritation, manifested by more or less slight swelling of the gums and augmented flow of saliva, is noticeable in many if not in most instances at the time of eruption of each tooth; and it is not difficult to understand that in some instances an increase of the local irritation may give rise to reflex disorders of various kinds. It is for the relief of disorders of dentition that the operation of lancing the gums of infants is performed. This operation which, however, does not fall within the province of a dental surgeon, has for its object the division of the abnormally indurated gum, and the release of the advancing tooth. It is obvious that the utility of this procedure must be extremely doubtful when it is carried out prior to the passage of the crown through the contracted bony orifice of the crypt in which the tooth lies until shortly before its protrusion through the gum. The operation may perhaps be reasonably expected to afford relief in cases where the advancing tooth can be distinguished beneath the tense and swollen mucous membrane.

Order of Eruption of Temporary Teeth.—The order in which the temporary teeth are erupted seldom varies. The lower central incisors are the first which appear. They are followed, after an interval varying between a week and two or three months, by the corresponding members of the upper set. After another

similar lapse of time, the lower, quickly followed by the upper lateral incisors, present themselves. Next, after like intervals, the first molars, and then the canines are protruded. Lastly, the second molars take their places, and complete the series. The annexed diagram (fig. 30) from Dr. Louis Starr's well known work, "Hygiene of the Nursery," may be helpful in fixing in

FIG. 30.

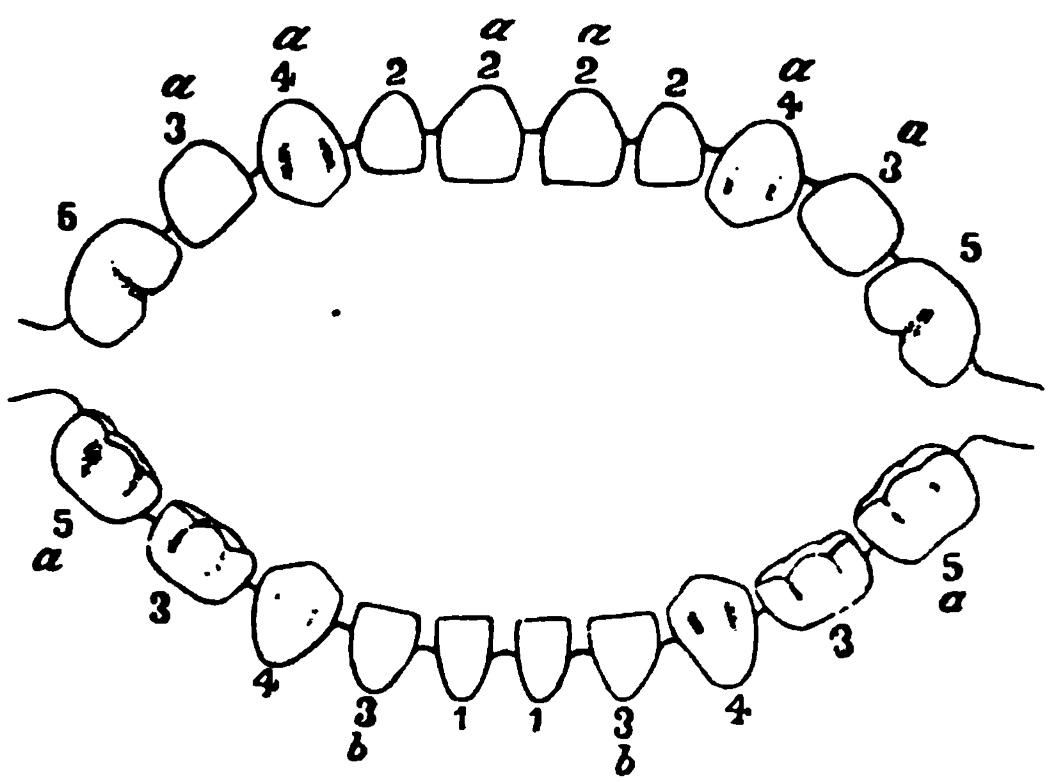


Diagram showing order of eruption of temporary teeth.

1 1, between fourth and seventh months. Pause of three to nine weeks. 2 2 2 2, between eighth and tenth months Pause of six to twelve weeks. 3 3 3 3 3 3, between twelfth and fifteenth months. Pause until the eighteenth month. 4 4 4 4, between eighteenth and twenty-fourth month. Pause of two to three months. 5 5 5 5, between twentieth and thirtieth months. The numbers 1 to 5 indicate the order of eruption of the groups of teeth, and the letters *a* and *b* the precedence of eruption of members of each group.

the memory the order in which the teeth appear, and the approximate length of the pauses which intervene between the eruption of the different classes.

By the time that the eruption of the temporary teeth is completed (between the second and third years), considerable progress has been made in the development both of the jaws and permanent teeth. The maxillæ have increased in size, and the fibro-cartilages uniting the lateral halves are completely ossified; the alveoli which had been absorbed to give exit to the teeth, have since grown up with the advancing organs, and now closely invest them; the angle of the lower jaw, which

FIG. 31.

Well developed set of deciduous teeth (projected upon a plane), with crowns of permanent teeth enclosed in their crypts exposed by removal of alveolar wall. (Natural size).

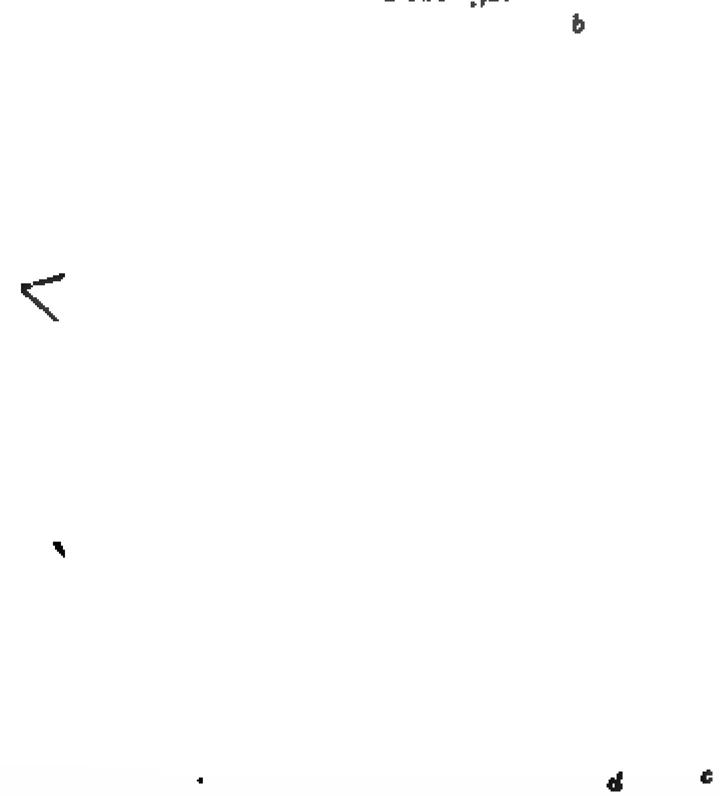
recently after birth is very obtuse, has become more acute, coincident with the development and lengthening of the ramus, and of the articular and coronoid processes. Excepting those of the wisdom teeth, the crowns of the permanent set are all well advanced in calcification, their progress being, however, proportionate to the periods at which their complete evolution is due. The incisors, canines, and bicuspids are completely enclosed

in bony crypts. The incisors are situated in the upper jaw above and behind, and in the lower jaw below and behind the roots of the teeth, which subsequently they respectively replace. The canines are deeply placed between the crypts of the lateral incisors and first bicuspids. The bicuspids lie within the divergent roots of the temporary molars. The molars, surrounded by incomplete casings of bone, occupy the portion of jaw posterior to the temporary set, extending into the ramus of the inferior, and the tuberosity of the superior maxilla. The anatomy of the jaws at this period is admirably displayed in figs. 31 and 32 from Wedl. It may be noted that this is the epoch at which the greatest number of teeth are held in the jaws at one time. The whole of the deciduous set, and the whole of the permanent set are present, and of these the wisdom teeth alone are still totally uncalcified.

Within two years after the completion of the temporary set a process is commenced by which their roots are gradually removed by absorption, until in time the teeth lose their attachment to the jaws, and are cast off one by one, to be afterwards replaced by the advancing members of the permanent set. The absorption does not begin simultaneously throughout the whole set, but attacks the teeth according to the order in which they are to be shed. It commences and proceeds, as a rule, at that part of the root towards which the permanent tooth is advancing, but occasionally it affects other parts at the same time. The wasting surface, which on examination is found irregular in outline and broken up into minute pits or depressions, resembles that seen in bone when undergoing absorption. Closely applied to the whole of this surface there is found a vascular papilla of slight depth, the absorbent organ, the active agent in the removal of the tissues. This papilla consists of a vascular and

cellular structure, the portion in contact with the teeth being entirely made up of large multiform nucleated cells. These cells occupy the pits in the wasting tissues. The papilla originates from the contiguous vascular layer of the alveolar periosteum, and it constitutes a special provision in the economy for the removal of the deciduous

FIG. 32.



Commencement of second dentition. Profile view from right side; front alveolar wall removed. (*a*) First permanent molars of upper and lower jaws erupted. (*b*) Upper permanent canine. (*c*) Lower permanent canine. (*d*) Mental foramen. Crown of bicuspids are seen embraced by the roots of temporary molars. Second permanent upper and lower molars are (in their crypts) imbedded in the maxillary tuberosity and coronoid process. Considerable absorption of the roots of the temporary incisors has by this time taken place. (Natural size).

teeth. Abundant evidence exists that the absorption is not (as was once supposed) due to the pressure of the

advancing permanent teeth, and the following are some of the main facts composing this evidence:—1st. In some of the lower animals, notably in the serpent, conditions exist during the evolution of successive sets of teeth, which prove beyond doubt that absorption of deciduous teeth, similar to what occurs in man, takes place independently of pressure. This fact has been clearly demonstrated by Mr. Charles Tomes. He has pointed out that the succession of teeth in snakes is endless, new teeth continuing to be developed at the inner side of the teeth already in place throughout the lifetime of the animal; that when a tooth is about to be shed, both it and the bone at its base are attacked by absorption, this taking place at its inner side before the outer side is at all involved; and that the advancing tooth moves forward, the delicate cells of its enamel organ remaining *in situ*, even after absorption has been effected to such an extent that the inner side of the old tooth has been cut away, and the successional tooth has passed into the space thus gained. "It is obvious that if the successional tooth had ever come into contact with its predecessor, these cells, at the point of impact, could not have escaped destruction."

2nd. Absorption of human temporary teeth frequently goes on at points remote from the permanent successors.

3rd. The permanent do not impinge upon the temporary teeth during their advance, and, on the contrary, are separated from them throughout by the bony walls of the crypts in which they are enclosed.

Retained Temporary Teeth.—It happens occasionally without discoverable cause that temporary teeth retain their positions long after the period at which they ought to be shed, and even until middle age. Sometimes they apparently form the sole obstacle to the eruption of their permanent successors, the presence of

which may then be usually recognised from the contour of the external alveolar plate within which they are hidden. It is remarkable that retention of temporary teeth, as regards incisors and canines, is much less frequent in the lower than in the upper jaw. Every now and again an adult patient presents himself, having one or more healthy looking and firmly fixed temporary teeth in position with absence of the members of the second set which should occupy the places. A reasonable time should be given for nature to take its course, but temporary teeth ought not to be allowed to remain beyond childhood—beyond the period when the second permanent molars are well in place. Extraction of such retained temporary teeth may be followed by one of two results—either the excluded permanent tooth will emerge, or the space which is left will become in time much diminished, and in a crowded set will be surely filled up by spreading of the teeth, which always takes place in these circumstances in youthful jaws.

Retained temporary teeth rarely endure beyond approach of manhood. In many cases in which long retained temporary teeth are at last shed, artificial teeth may be called for, to fill towards the front of the mouth unsightly gaps which have shown no tendency to close, but which might have become obliterated had the temporary teeth been removed during youth. Further reference to this subject will be made in the chapter on "Irregularities of the Teeth.'

Retained temporary crowns may be of good colour and look healthy, though frequently less translucent than the permanent teeth. Molars are generally found to be much worn down upon their masticating surface; they occupy usually a lower level than the adjacent permanent teeth, and sometimes a temporary molar seems held in place mainly by its neighbours, which, leaning

towards each other keep it in position. If the cervical edge be carefully examined with a sharp dental probe, the peculiar contour of the temporary crown may often be distinguished, and it will be found that the enamel margin ends suddenly, and that there is as it were a ridge all round the tooth. On seizing such a tooth with forceps it will commonly be recognisable that the only resistance to its removal is formed by its impaction between its neighbours. When the tooth comes away

FIG. 33.

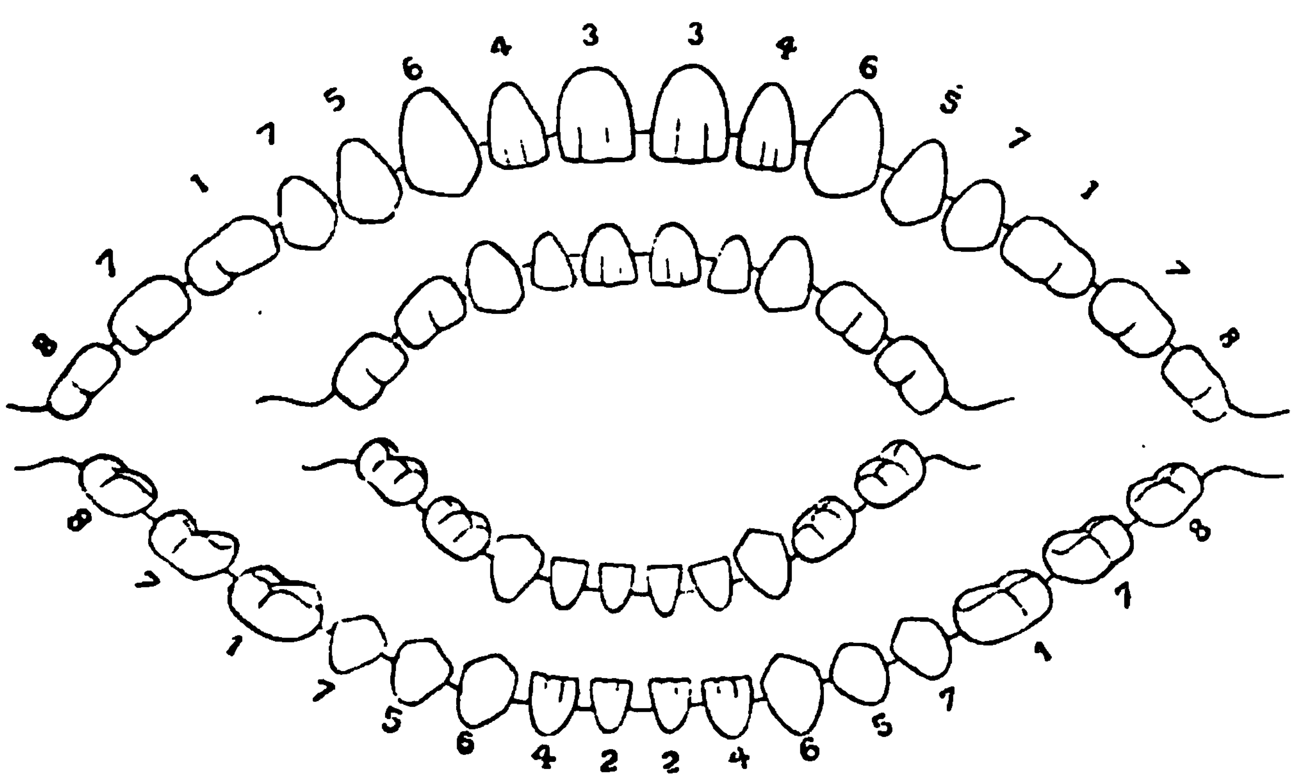


Diagram of second dentition, showing relation between permanent and temporary teeth. Figs. 1, 2, 3, &c., indicate the groups of teeth and the order of their appearance.

it is often found to have little or no roots, and the crown of its permanent successor may be perhaps seen or felt in the socket beneath.

Eruption of the Permanent Teeth.—The process of eruption of the permanent teeth closely resembles that which has been described as occuring in the first

dentition. By the time each temporary tooth is shed, absorption has commenced in the plate of bone which up to this period has closed the crypt of the permanent successor, and this absorption proceeds until the opening is large enough to permit the free passage of the emerging crown. When the crowns of the teeth have become fully protruded the development of the alveoli again becomes active, and the bone in time closely embraces the necks of the teeth, and invests the roots in accurately fitting sockets.

The age at which second dentition commences in different individuals varies like the first, but the order in which the teeth appear is rarely irregular (see fig. 33 from Dr. Starr). The following may be taken as average dates at which the eruption of the different teeth is completed. The teeth of each class appear somewhat later in the upper than in the lower jaw:—

	YEARS.
First molars . . . . . } Central inferior incisors . . }	5 to 7
Central superior incisors. .	6 to 8
Lateral incisors.	7 to 9
Anterior bicuspids	8 to 10
Canines	9 to 12
Posterior bicuspids . . .	10 to 12
Second molars	12 to 14
Wisdom teeth	17 to 25

The eruption of the permanent teeth is very rarely, if ever, attended with constitutional disorders due to reflex nervous disturbance, such as occasionally accompany first dentition; and local irritation is rare, except in the case of the lower wisdom teeth.

Difficult eruption and impaction of Lower Wisdom Teeth.—The protrusion of the lower wisdom teeth is often

attended by considerable suffering. They make their appearance after the completion of dentition, at the time when in many cases owing to insufficient backward development of the horizontal ramus of the jaw, crowding of the teeth exists, and the space which should remain for the wisdom teeth is encroached upon by the second molar. The wisdom teeth in their advance thus become wedged between the distal surface of the second molar and the coronoid process. This condition —commonly spoken of as "impaction" of the wisdom tooth—appears sometimes enough alone to give rise to considerable swelling and inflammation of the gum, and the mischief becomes aggravated when the opposing teeth of the upper jaw during mastication come forcibly in contact with the swollen tissues which overhang the emerging crown. In many cases the inflammation arises from cold, and it is sometimes difficult to determine whether it has commenced around the tooth or has spread forward from the tonsil or pharynx. The inflammation, starting at the gum, if allowed to run on, spreads to the alveolar periosteum, and to the uvula, soft palate, and tonsil; and lymphatic glands beneath the jaw become swelled and painful. The wisdom tooth and often the molars in front become exquisitely sensitive to the touch owing to extension of the inflammation to their sockets. Movement of the lower jaw is always more or less impeded by the swelling, and in later stages of the inflammation force is sometimes needed to open the mouth. Closure of the jaws of this kind, whilst chronic inflammation exists in connection with an impacted wisdom tooth, may endure for many weeks. The closure is mostly altogether due to inflammatory swelling in and around the muscles, but it is occasionally spasmodic in its nature. The masseter and internal pterygoid muscles are mainly affected in spasmodic closure. The nature of

the case becomes apparent when the patient is put fully under the influence of an anæsthetic; for then in a spasmodic case the muscles relax and the mouth is easily opened, whereas if the closure be due to inflammatory swelling or adhesions, force will be still necessary to separate the jaws.

The pain, which varies with the amount of inflammation, is often severe, and sometimes throbbing in character, and is increased by attempted movements of the jaw and by swallowing. During the acute stage the pain is mostly localised, but in chronic inflammation around impacted wisdom teeth, and even in cases where very slight or no traces of inflammation are detectable, neuralgic pain spreading over the side of the face, and particularly affecting the ear, is a very common symptom. The acute symptoms are attended with considerable febrile disturbance. If the disease runs on suppuration takes place, and pus flows or may be pressed from within the gum and alveolus; or in some few cases pus may burrow and point externally through the cheek, or at some distant part. Many cases of this kind have been reported. In one (reported by Mr. Henry Sewill in *British Dental Journal*, 1869), an abscess arising from an impacted lower wisdom tooth, formed, pointed and burst upon the cheek about an inch from the corner of the mouth. In some cases suppuration with extensive burrowing of pus through the tissues of the neck takes place. In all cases of inflammation of the face and neck in the region of the angle of the jaw in patients between the ages of seventeen and twenty-five, unless other sufficient causes be evident, a careful examination of the teeth should be made, lest the true origin of the mischief be overlooked.

On occurrence of suppuration the symptoms may slowly subside, or the inflammation may remain chronic,

increasing again into the acute form from time to time, under the influence of cold or other irritation. In a few instances necrosis of the wisdom tooth results, and in rare cases others of the adjacent teeth, and more rarely again portions of the alveoli or jaw may also lose their vitality.

It must not be supposed that in every case of impaction—every case in which, owing to want of space, the full eruption of a wisdom tooth is rendered difficult or impossible—inflammation necessarily follows. It is only in a small minority of cases that inflammation at any time supervenes, and it is only in exceptional instances that the inflammation assumes an acute character, and in still rarer instances that it becomes extensive, or followed by more than trivial strictly localised suppuration. Many cases occur in which lower wisdom teeth remain throughout life either partly hidden or completely buried behind the second molar, without the patient being aware of their presence. Examples where the tooth is rising vertically rather than where it lies in a sloping or horizontal position are those most commonly attended by inflammation. On the other hand, the absence of easily recognisable inflammatory or other objective symptoms does not necessarily imply always in these cases that the impaction is not a cause of irritation. On the contrary, the cause of neuralgia of the side of the face, and particularly pain referred to the region of the internal ear, is in a considerable number of cases clearly traceable to an impacted lower wisdom tooth, in the neighbourhood of which no inflammation or other sign of disease may be readily discoverable. The neuralgia in some few of these cases seems really due to pressure upon or irritation of the trunk of the inferior maxillary nerve by the root of the wisdom tooth. The apex of the root

is even in normal cases in very close propinquity to the nerve canal, and in some instances encroaches upon it.*

Treatment of Impacted Lower Wisdom Tooth.—In a great number of simple cases of impaction immediate relief may be afforded, and, at the same time, a permanent cure effected by excising the thick flap of gum which overlays to a greater or less degree the crown of the tooth. Sometimes the tooth is completely hidden; sometimes one or other cusp alone is visible. The mere lancing or division of the gum rarely does permanent good, as the divided parts fall at once again into apposition and become rapidly re-united. The flap of gum should be seized with a pair of strong narrow-bladed dissecting forceps, and completely dissected away with a small bistoury or curved scissors. The gum is usually tough, slippery and difficult to hold; and unless firmly fixed, it is often by no means easy to dissect the flap cleanly off, and at the same time to avoid cutting the cheek. In some cases an artery forceps may be conveniently used to grip the flap of gum by pushing one blade beneath and then closing the forceps. Sometimes the fixing may be done with a small tenaculum or hook. The hæmorrhage on the first incision is enough usually to hide the part and an assistant should be at hand provided with small sponges held in a dressing forceps to wipe away the blood, and give the operator a view of the part. The operation is sufficiently painful to justify use of an anæsthetic. Nitrous oxide answers well and affords enough time, if the surgeon stands ready with instruments in hand. The success of the operation depends upon the thoroughness with which the emerging crown is laid bare, and care must be exercised to remove enough tissue, especially behind, where the gum is thickest and toughest.

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* See chapter on Neuralgia.

If a wisdom tooth, as sometimes happens, be malplaced, and with the crown so directed as to render it useless in mastication, it should, if the cause of inflammation, be removed. The extraction of a tooth may also be called for in cases which take a rapid, bad course, or which have been neglected until extensive inflammation and suppuration are present. It often happens, however, in these instances, that the tooth is so impacted as to render its extraction extremely difficult or impossible. This is especially the case where the tooth is advancing in an oblique direction—sometimes it may be nearly horizontal—and with the anterior margin of the crown impinging upon the distal surface of the second molar. A careful examination must be made before an operation is attempted. In some few cases of this kind it is possible to break or excise the crown from the root, the patient being under the influence of an anæsthetic, and extract the root in a second operation. But, with few exceptions, cases of impacted lower wisdom teeth, in which relief afforded by space is called for, are best treated by extraction of the second molar. This allows the impacted tooth to advance slowly into the vacant space. Where the second molar is extensively carious, there seldom need be hesitation in proposing this operation.

A crown of a wisdom tooth advancing obliquely and impinging upon the distal surface of the second molar will in some instances be found partly lodging within a carious cavity, which is apt in these cases to form at the point of contact. Decay at the lower margin of the posterior surface of the second molar is set up by the constant lodgment and decomposition of food particles in the wedge-shaped space between the two crowns. As soon as softening takes place the wisdom tooth advances, and this process goes on until the two

crowns become immovably locked together. Several examples of this condition (one presented by Mr. Henry Sewill) are to be found in the Museum of the Odontological Society. This condition renders impaction more complete, and it will under these circumstances be found impossible in some instances to remove one without the other tooth. If the second molar be extensively decayed the crown may in some cases be excised and the roots extracted in a second operation. Extraction of the first molar or even of a bicuspid, which may be chosen if decayed, will give relief, but more slowly, to the crowding.

To reach the wisdom tooth when the jaws are closed they must be carefully forced apart with a screw gag, the patient being anæsthetised. When inflammation has been going on for some time round an impacted wisdom tooth, it is often so loosened and extruded that it may be extracted with comparative ease. Often it may be easily forced from its socket with an elevator. When suppuration has supervened extraction of the tooth becomes usually still more easy.*

Beyond the operative procedures just described, the treatment of inflammation associated with impacted wisdom teeth is the same as that of ordinary dental and maxillary periostitis given in a later chapter, and consists mainly of assiduous use of hot fomentations, confined as much as possible to within the mouth, and incisions through the gum and swollen periosteum of the jaw, in order to relieve tension, to give exit to pent-up pus, and prevent it from burrowing or bursting externally through the skin.

In cases of intractable neuralgia (particularly in young subjects) affecting the side of the face and the ear, in

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* See chapter on Extraction of Teeth

which no local cause can be discovered, but in which an apparently healthy although impacted wisdom tooth is present, it may sometimes be right to extract the tooth or the second molar, in the hope of relieving irritation of the nerve trunk, which may exist without recognisable local signs.

Completion of Development of the Jaws.—Throughout the entire period of their growth the process by which the maxillæ are moulded into their destined form is similar to that which takes place in all developing bones. It consists, on the one hand, of continuous deposition of bone, and on the other of occasional absorption. It has been already explained how the processes of growth and absorption alternate during dentition and the development of the alveolar border of the jaws. Enlargement of the maxillary arch is produced mainly by deposition of bone upon the facial surface, and as new layers of bone are deposited absorption takes place upon the lingual surface. In the same way in the development of the posterior portion of the lower jaw, whilst the ascending ramus is increasing in size by the deposition of bone upon the posterior surfaces of the coronoid and condyloid processes, absorption is going on upon these parts anteriorly, and thus the bones are moulded into their destined form. The deposition of new material is principally sub-periosteal, but it also takes place beneath the articular cartilage of the lower jaw, and at the surfaces contiguous to the cartilages, which in the infant unite the separate portions of bone in both maxillæ; and the increase in the bulk of the jaws is thus entirely affected, not by interstitial growth or expansion of the bones, but by constant additions to the external surfaces.

Up to a certain period in the growth of the jaws, as previously explained and illustrated (figs. 31 and 32), there is

not sufficient room in the alveolar arch for the crypts of the developing permanent molars, which, therefore, are enclosed in the base of the coronoid process of the lower, and in the tuberosity of the upper jaw. The space taken up by the ten anterier permanent teeth almost exactly corresponds to that occupied by the milk teeth, and it is, therefore, in the backward direction that the required increase in size of the arch takes place. The depth of the bones becomes greater in accordance with the dental and muscular development. Examination of a large series of human maxillæ of different ages enabled Sir J. Tomes to demonstrate the fact, first pointed out by John Hunter, that the growth of the alveolar border, during both first and second dentition, follows and is dependent upon the growth of the teeth, and that the position of the teeth is not, as was once believed, pre-determined by independent growth of the bone. This fact has also received confirmation from the observations of Mr. Chas. Tomes, upon the mode of attachment of the teeth in fishes and reptiles. He has proved that in the attachment of a tooth by simple anchylosis, or by ever so rudimentary a socket, as it takes place in the varied species, the bone is modelled to the tooth in full subserviency to the position of the tooth, and that the tooth does not come to take its place upon a spot pre-determined for it by any disposition of the bone, made prior to its advent.

The portions of bone which give attachment to the muscles of mastication increase in bulk as these organs develop in size and power.

When the teeth are lost from age or other causes, the alveoli waste by absorption ; and at the same time mastication being gradually discontinued, the muscles, together with the portions of bones to which they are attached, undergo atrophy, and the jaws assume the peculiar form characteristic of age.

Embedded Permanent Teeth. — It happens occasionally that permanent teeth remain embedded within the jaws instead of making their appearance at the natural epoch of their eruption. It has been just explained, and illustrated in figs. 31 and 32, that at one period in the growth of the maxillæ, before the jaws have attained their full size, enough space for the extended arrangement of the set in an unbroken arch does not exist, and the teeth are crowded within the jaw,

Fig. 34.

the canines and bicuspids being deeply placed, whilst the upper and lower wisdom teeth are situated in the tuberosity of the upper and in the ramus of the lower jaw respectively. If, owing to arrest of development or other cause, the jaws remain unduly small or contracted,

there may never exist enough room for the entire set of teeth to take their places in the dental arch, and some of the set, although fully formed, may remain buried within the bone. This condition, although it may happen in the case of any tooth, most commonly arises, as might be expected, with those teeth such as wisdom teeth, canines and bicuspids -which are cut at a late stage of dentition, when the whole available space in an abnormally small maxilla may be taken up by the rest of the set. The eruption of such teeth may be also in the same way prevented by the presence of supernumerary teeth or by temporary teeth holding their position after the time at which they ought to be cast off. Cases of this latter kind will be described and illustrated in later pages.

FIG. 35.

In another class of cases embedded teeth hold such abnormal positions within the bone that, although room may exist for them in the dental arch, their eruption in their proper situation is impossible. In some of

these instances, there is evidence that the malposition is due to deflection of the growing tooth from its normal course by obstacles, such as temporary teeth or supernumerary teeth, but in others the tooth is situated far from the alveolus, and its misplacement cannot be accounted for. Fig. 34, from Mr. Heath's work,* shows an upper canine situated within the jaw in a position which it may have possibly assumed in consequence of want of space, whilst fig. 35 from the same work, exhibits an upper canine, lying horizontally in the floor of the nose, with the crown directed backwards—a misplacement which cannot be accounted for. Fig. 36 from Salter,† shows an embedded molar in the lower

FIG. 36.

jaw. The accompanying cut (fig. 37), from the Transactions, 1897, illustrates a case exhibited by Mr. Maggs at the Odontological Society. The first bicuspid lies embedded in the substance of the lower jaw with the

* Injuries and Diseases of the Jaws, 3rd edition, 1884.
† Dental Surgery, 1874.

apex of its root in contact with the socket of the canine. In all these specimens the bone has been cut away to expose the buried tooth. Similar specimens are preserved in the Museum of the College of Surgeons, showing teeth embedded in almost every position in the maxillæ.

FIG. 37.

Embedded teeth, especially those regularly situated within the bone, sometimes make their appearance

after a lapse of time when room is afforded by the loss of other teeth; and the eruption of such teeth late in life has given rise to the unfounded belief in the occasional occurrence of a third dentition. Every dental surgeon becomes familiar with cases in which in a patient with edentulous gums, and perhaps wearing a complete set of artificial teeth, one or other buried members of the set—most often wisdom teeth or canines—begin after a time to emerge or become exposed through the wasting of the alveolar border of the jaw.

In the majority of instances, embedded teeth remain throughout life, without the patient being aware of their existence. In some cases, in consequence of extension of periostitis from around overlying or neighbouring teeth or other causes, inflammation may be set up in the cyst of a buried tooth; and in all cases of deep-seated inflammation within the jaws where the cause is not evident, the possibility of the presence of a buried tooth must be therefore borne in mind. The diagnosis would be confirmed by exploration. The thin external plate of bone covering the tooth can be easily penetrated for this purpose, if it have not at some point already given way to pressure of confined exudations or pus, and the cavity can be searched with a probe. The presence of a suspected tooth may be verified by the Röntgen rays. This method has been applied in cases of "irregularity," where members of the set have been missing; and some cases of this kind are described and illustrated in the chapter on "Irregularities of the Teeth."

A tooth being discovered its extraction presents as a rule no serious difficulty. The enclosing bone must be opened to the slight extent necessary with a dental drill, followed by a small trocar or bone forceps, and the tooth being gripped at a convenient point with extracting forceps must be carefully detached and with-

drawn. A cure will be hastened by antiseptic lotions, such as Condy's fluid or carbolic acid (1 in 50), with which the mouth may be frequently rinsed and the cavity in the bone syringed.

In some few instances, buried teeth become the centre of cystic disease or of other morbid growths. Such growths connected with teeth are described in a later chapter.

ABNORMALLY FORMED TEETH.

Abnormalities in Size of Teeth.—The size of teeth varies very much in different individuals. In the vast majority of cases teeth composing a set are of sizes proportional to each other; but a set may be disproportional relatively to the size of the jaw, being made up of comparatively very large or very small teeth. A large set in a small jaw gives rise to crowding—a condition discussed in the next chapter. Single members of a set may in proportion to the rest be abnormally large or small, but variations in this respect are very rare, except in the upper lateral incisors and in the wisdom teeth. The laterals occasionally are very small, round, conical and pointed in shape, resembling a class of supernumerary teeth (figs. 51 and 53), with which they must not be confounded. In some uncommon cases the incisors and canines and, in still rarer instances, a whole set has partaken of this character. Such teeth have been likened to rats' teeth. Wisdom teeth are, above all, most variable in size. They are sometimes represented by stunted conical teeth, also not unlike in character the peg-shaped supernumerary teeth illustrated in this chapter (figs. 51 and 53). Wisdom teeth are less frequently of great size; every now and then, however, they are met with having crowns half as large again as the second molar. Such large teeth often—although by no means always—have stunted roots. It will commonly be found that teeth of any class with small crowns may possess roots of full or great size and *vice versâ*—a point which must be borne in mind in several operations of dental surgery.

Hypoplastic Teeth. Syphilitic Teeth.—A peculiar malformation associated with hereditary syphilis affecting the incisors and canines of the permanent set only, and being most marked in the upper central incisors, was first described many years ago by Mr. Jonathan Hutchinson.* Syphilitic teeth (figs. 38 and 39) are short, small and peg-shaped. Their cutting edges are narrow and marked by a characteristic broad crescentic notch. Horizontal

FIG. 38.

Typical syphilitic upper and lower incisors.

FIG. 39.

Syphilitic upper central incisors, and honeycombed mercurial permanent molars, carious, from boy æt. eleven. At one side the temporary molars, carious, are still in place.

* Papers on Syphilitic, Stomatitic and Mercurial Teeth, &c. Ophthalmic Hospital Reports, 1859. Transactions, Pathological Society, 1875. Transactions, Odont. Society, 1889.

notches, or furrows, and honeycomb pits not of syphilitic origin often exist on the same tooth. The colour of the teeth is bad—often a dirty grey shade. The central incisors Mr. Hutchinson looked upon as the "test teeth." The tissues of syphilitic teeth are soft and ill-made, so that they soon become worn down and lose in great part their characteristic marks. The enamel towards the neck is usually smooth and free from visible defect. A striking connection has been observed between this deformity of the teeth and a syphilitic disease of the cornea—interstitial keratitis. The subjects of inherited syphilis who present marked examples of interstitial keratitis, have almost invariably typically malformed teeth, and those who have such teeth scarcely ever escape interstitial keratitis; whilst syphilitic children who are liable to suffer in after life from phagadænic affections of the mouth and throat usually show nothing peculiar in their teeth.

Although the characteristic appearances of true syphilitic teeth are of unequivocal significance, and can hardly be mistaken by an experienced observer, it must not be forgotten that many honeycombed and malformed teeth resemble syphilitic teeth; and great caution is therefore necessary in pronouncing a diagnosis from the teeth alone. It is only in a small proportion of undoubtedly syphilitic children that teeth of this special type appear. Typical syphilitic teeth are certainly not found in five per cent. of children displaying other unequivocal signs of the hereditary taint, and comparatively are rarely met with even in the worst cases.

"Honeycombed" Teeth.—A considerable variety of malformed teeth with defective surfaces—pitted, rocky, ridged or spinous—are usually classed as "honeycombed" teeth. These teeth are almost sufficiently described by their names. In spinous teeth the cusps

of molars seem pinched, drawn out and pointed, and the crowns of incisors and canines flattened and elongated into thin processes towards the cutting edge. The defects rarely involve the whole crown. They are mostly confined in the molars to the cusps and masticating surface. In the incisors and canines the markings may be confined to a narrow space along the cutting edge. At this point the disfigurement always starts, thence extending to a varying degree over the surface towards the neck. The rest of the tooth is often well formed and of good structure externally. The defect is mainly confined to the enamel. These teeth were styled by Mr. Jonathan Hutchinson "stomatitic" or "mercurial" teeth. A more minute description of the different varieties of hypoplastic teeth has been furnished by later observers, and will be presently given. Mr. Hutchinson was perhaps the first to describe and try to trace out the causation of these defects of development. He believed that in cases in which great and general damage to the enamel of the permanent set of teeth is observed, it ought to lead us to suspect that the patient has in early infancy passed through an attack of stomatitis, attended with inflammation of the tooth sacs. Mr. Hutchinson believed that if all the bicuspids have good white enamel, while all the first permanent molars show absence of enamel and spinous discoloured surfaces, it may with confidence be assumed that the child took mercury in infancy, or that some cause for a similar kind of stomatitis then existed. As to the cause of the stomatitis, although he did not assert that mercury is the only cause, he believed that by far the most important cause of defects in enamel development in the permanent set of teeth was the use during infancy of mercury in one or other form. The "test teeth" in these cases are the first permanent molars. The bicuspids often and the

second molars usually are unaffected. The disease of the eye known as lamellar cataract, which is not congenital and not syphilitic, was observed by Mr. Hutchinson in concurrence with honeycombed teeth, particularly in children who had suffered from convulsions in infancy.

It is to some extent still an open question whether there is any correlation of development between the eyes and teeth, but Mr. Hutchinson held to the belief that the connection between the two phenomena referred to was not to be so explained, but that the lamellar cataracts were due to convulsions in infancy, and the damage to the enamel of the teeth to stomatitis, which might be caused by mercury given for the convulsions.

Mr. Hutchinson also found that some adult patients with honeycombed teeth displayed an unusual susceptibility to the action of mercury, and believed that it was owing to this idiosyncrasy that the teeth had suffered from what was given in infancy. If this view were correct, honeycombed teeth might rank as revealing symptoms, and might be of value in giving information as to individual susceptibilities which could not have been otherwise recognised.

Since Mr. Hutchinson's observations were published, the whole subject of dental hypoplasia has been investigated by numerous observers, and whilst the soundness of Mr. Hutchinson's fundamental facts has been to a great extent established, our knowledge of the causation of the structural defects has been extended, and progress has been made in classifying and explaining the significance of the different varieties of structurally defective teeth. These structural defects have been investigated especially by Grevers,* of Amsterdam, Zsigmondy, of Vienna, Leon Williams, and Norman G.

* Trans. Odont. Soc., 1895.

Bennett,* and have been well named by Dr. Grevers, "hypoplasia." Such teeth of the permanent dentition may be divided, according to Mr. Bennett, into two classes. In that containing the larger number of cases, the teeth usually affected are the first molars, incisors and canines. The molars show a deficiency of enamel, which is also opaque and discoloured, almost always extending over the coronal surfaces, and for a variable distance over the labial and lingual aspects. In many cases the tips of the cusps appear to be normal, and stand out prominently from the rest of the crown, and the transition to normal enamel towards the gum margin is usually sudden and marked by a definite ledge. The upper centrals show deficient enamel of a similar kind, extending from the extreme incisive edge to a level corresponding to the line of transition to normal enamel in the first molars. The laterals may be affected to a less extent, or may escape entirely, and the canines frequently have the tip of the cusp nearly normal, with a ring-like depression above. The lower incisors and canines are almost always affected, in a manner and to an extent to be expected from observation of the upper teeth ; but the chronology of development appears to be more regular and certain in the lower teeth than in the upper. The relative positions of the marks on the upper teeth vary considerably in different cases, that is to say, that in two cases in which the central is affected for about half its labial surface, the lateral may be involved for about a third in one and be nearly or quite normal in another. In the lower teeth, however, cases showing to the same extent an affection of the centrals, usually correspond also as regards the condition of the laterals and canines respectively. The bicuspids and second

* Trans. Ophthalmol. Soc., 1901.

molars are usually quite normal. This type of case is well illustrated in figs. 40, 41 and 42, and the parts of the teeth synchronously affected, suggest the inference that some cause has acted to the detriment of their calcification, from very shortly after birth until about two years of age, or even during a shorter period in many cases.

In the less frequent cases of the second class the condition is quite different. The teeth most usually affected are the incisors and cuspids, and, less frequently, the bicuspids; and the affection takes the form of a horizontal depressed line of deficient enamel, most clearly seen on the labial surfaces. In the less severe cases this line may be merely indicated by a row of small pits. The incisive edge is perfect, and the determining cause presumably acts for a brief period some time during the first four years of life, or in some cases later. The second molars are very occasionally affected.

In some cases a "terraced" condition may be noticed, showing a repetition of periods of imperfect calcification at different stages of development.

Microscopic examination shows that the dentine is also often affected. The enamel appears thin in the regions of depression, and in parts may be entirely absent. The dark lines found in normal enamel, known as the striae of Retzius, and supposed to represent the outer surface of the enamel at an earlier period of development of the tooth, are found in abundance and with marked characteristics.

These lines, it has been pointed out by Grevers, follow the "incremental" lines of enamel growth, running in a direction downwards and inwards towards the neck of the tooth; they are said to run at an angle of 30° to 35° with the periphery of the dentine. The deposition of enamel from within outwards, while occurring

simultaneously over the whole of what is at the time the outer surface of the enamel, is not uniform in its

FIG. 40.

Ridged and honeycombed teeth, boy æt. sixteen, subject of lamellar cataract. Had fits in connection with very late dentition in early childhood. Much calomel was given during a whole year (from one to two years of age).

FIG. 41.

Honeycombed teeth, girl æt. nine, subject of lamellar cataract. No evidence as to fits or mercury.

FIG. 42.

Stomatitic or mercurial teeth of type sometimes mistaken for syphilitic.

progress but intermittent; and the striae of Retzius, existing to a pathological degree in these teeth, indicate the periodic increments or additions. The dentine is also characterised by large numbers of interglobular spaces; indeed, the whole appearance, macroscopic and microscopic, is obviously indicative of imperfect calcification, a condition in which the calcospherities have not completely coalesced to form the normal tissue.

Dr. Leon Williams* has investigated the histology of these teeth both in man and animals. He has prepared a large number of specimens, showing the condition of the enamel in the neighbourhood of the sulci, where it is incompletely formed, and in the slighter cases, where impaired translucency and discolouration are the only characteristics visible to the naked eye. In the latter, the most obvious features are marked striation of the individual enamel prisms and stratification in the layers of deposit of the enamel, combined with increased pigmentation and granularity. In some cases, deflection of the enamel prisms at the lines of stratification is clearly visible. In the former, it is seen that the fissures in the enamel frequently expand on reaching the outer surface of the dentine into flask-shaped spaces, a condition partly due to incipient caries. In other situations in the vicinity, granular amorphous masses of enamel exist, from which tracts of imperfect enamel lead towards the surface of the tooth. In thus directing his attention to the investigation of those teeth which, to the naked eye, appear but slightly affected, Dr. Williams has shown that even in these the structural defect may be really very great, and also that between the least and most severe cases the difference is one of degree and not of kind. The importance of these facts in their bearing on

* Dental Cosmos, 1897.

the etiology and progress of dental caries will be pointed out in the proper place.

Temporary teeth are frequently said by medical writers on rickets to show defective enamel, but it is very rare to find the temporary teeth marked in the clearly defined synchronous manner in which the permanent ones are, although the enamel of the deciduous molars may be irregularly pitted. These teeth are almost completely formed as to their crowns by four months after birth.

With regard to the causation of hypoplasia, Mr. Norman G. Bennett* has recently published the results of a large number of observations, affording evidence in favour of the infantile origin of lamellar cataract. A large number of cases of this disease all had hypoplastic teeth of the kind described in the first class above, and in no case were any teeth found corresponding to those in the second class. He also collected a number of cases of hypoplastic teeth not associated with lamellar cataract, in which definite histories of different affections at an early age were obtained.

Mr. Bennett is unable fully to support all Mr. Hutchinson's views; and points out that stomatitis of any degree of severity is too infrequent a disease to account for the large number of cases of hypoplastic teeth found in children of the poorer classes. Those cases sometimes seen of isolated affection of bicuspids may, however, very likely be due to disease of the corresponding temporary molars.

He found no evidence that rickets, *per se*, was a frequent cause, and points out that as regards those cases occurring during early infancy, specific illnesses are not commonly traceable, although conditions of general disturbance of health, for which evidence is

* Trans. Ophthalmol. Soc., 1901.

afforded by convulsions, may often be found. Mr. Bennett believes that errors of feeding and mal-nutrition constitute the common cause of lamellar cataract; that this is also the cause of the type of defective enamel usually found in association with lamellar cataract, as well as of the large class of hypoplastic teeth which occur without any association with any disease of the eyes. Mr. Bennett holds that the type of tooth described in the second class above, is without doubt more often due to an exanthematous fever than to any other cause, and in its origin is to be clearly distinguished from the former class.

Mr. S. Spokes* has published some valuable and suggestive observations and statistics, throwing light upon the incidence of dental hypoplasia among the different classes of children. He examined the mouths of 1,904 school children, at the period after shedding of the temporary teeth. Of these children 258 were college boys—sons of well-to-do parents. The rest were pauper children, partly inmates of the workhouse, partly of the isolation homes provided for pauper children suffering from contagious ophthalmia. Amongst the 1,904 children were 147 cases of dental hypoplasia, *i.e.*, 17·7 per cent. They were distributed thus:—

College boys ...	258	12	4·6 per cent.
Poor Law ,, ...	841	60	7·1 ,,
Ophthalmic ,, ...	103	17	16·5 ,,
Poor Law girls ...	622	47	7·5 ,,
Ophthalmic ,, ...	80	11	13·7 ,,

Mr. Spokes observes that there might be some temptation to try and establish a relationship between a tendency to eye affections and hypoplastic teeth; but he prefers to leave it unexplained.

* Jour. of Brit. Dent. Asso., 1896.

It would, indeed, seem impossible to establish any but a fortuitous relationship between a chronic inflammation of the conjunctiva communicated by infection, and a pre-existing structural dental defect; but Mr. Spokes' observations suggest another consideration. The fact that an amount of disease prevails among the infants of the poor, enormous in comparison to that occurring among the well-to-do classes, was pointed out in the section on the disorders on dentition. The exanthemata and all other disorders of infancy, including those due to improper feeding, occur in their most aggravated forms in pauper children. These diseases seem to leave their mark upon the whole constitution, as well as upon the developing teeth; and it may well be that delicate children of this class are, more than robuster individuals, prone to become affected by ophthalmia, and other similar maladies. The point of importance to be noted here is, that the incidence and progress of dental caries are governed largely by the inherent qualities of enamel and dentine, and it seems evident that these qualites depend largely upon the influences affecting general and local nutrition, during early infantile development. The importance of these observations will be more apparent in the examination of the etiology of dental caries, entered into in later chapters.

To sum up the more important facts relating to dental hypoplasia, it would appear:—1st. That typical syphilitic teeth are mostly accompanied by other evidences of the inherited taint, such as skin affections and interstitial keratitis, while honeycombed teeth are occasionally associated with a non-syphilitic eye disease, lamellar cataract, with infantile convulsions, and with stomatitis often but not always caused by mercurial treatment during the enamel forming period.

2nd. That in inherited syphilis the teeth mostly affected are the upper incisors, the honeycombed condition being most conspicuous in the first permanent molars.

3rd. That these conditions may both be present in the same individual.

4th. It by no means happens that every case of inherited syphilis is marked by typical mal-development of the teeth. On the contrary no characteristic defect is visible in the vast majority of instances.

5th. Syphilitic teeth are due to causes acting upon the entire tooth germ during development, whereby not only the structure but the whole form of the tooth is modified. Honeycombed teeth and other forms of hypoplasia are due to causes acting upon the enamel and dentine pulps during calcification, and interfering with the proper formation of the tissues.

Syphilitic and hypoplastic teeth illustrated in the accompanying engravings, were taken from patients at Moorfields Ophthalmic Hospital. Figs. 38, 39, showing typical teeth, are from patients undoubtedly subjects of hereditary syphilis, and in one (fig. 39) there is a history of mercurialism also. Figs. 40 and 42—honeycombed teeth—are from patients with lamellar cataract and to whom mercury had been given in large quantities in early childhood. Fig. 38 may be contrasted with fig. 42; the former syphilitic, the latter mercurial, or stomatitic central incisors. Fig. 41 well illustrates the common occurrence of well-made bicuspids in honeycombed sets of teeth.

Treatment.—Syphilitic and honeycombed teeth do not necessarily call for interference. Pits, fissures and grooves, especially if they extend to the dentine, are of course very apt to become the seat of carious action. The teeth must be frequently examined and decay be dealt with as it appears. Enamel-covered pits and

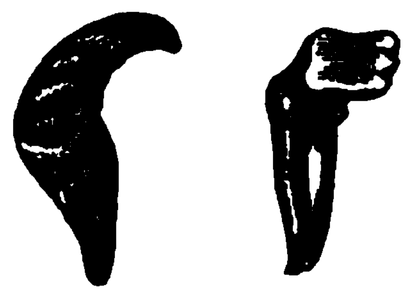
depressions often remain permanently unaffected. None save gold or other metal fillings are permanent on the faces of front teeth. Large metal fillings in these situations are, however, very disfiguring, and these teeth can sometimes be most satisfactorily treated by inlaying with porcelain—a process described in a later chapter. The flattened, pitted and drawn out or spinous edges of front teeth often, as time goes on, present an unsightly appearance. The surface becomes covered with discoloured tartar which, filling the small pits, is difficult to dislodge. It is a good plan in some cases at the approach of adult age to file or cut down and polish these ragged surfaces and edges, with care not to approach the pulp chamber. This may leave the teeth unnaturally short but will vastly improve their appearance.

Dilaceration.—When the mode of development of the teeth is considered, and it is remembered that they are liable to injury at the period when they are but partially calcified, it is easy to understand why teeth are occasionally met with the crowns and roots of which are more or less distorted. In such cases some force—such as a blow—has been transmitted to the developing organ, by which a part or the whole of the crown has become displaced, without severance of its connection with the uncalcified portion of the pulp, and has become subsequently fixed in its malposition by completion of the process of calcification. This kind of injury has been termed dilaceration. Section of such teeth displays evident marks of the bending which the tissues underwent in the soft state. It is possible that a tooth might be distorted during growth to the extent of dilaceration in consequence of crowding and pressure within the jaw from want of space, and this opinion is strengthened by the fact that the deformity seldom or never occurs except

in teeth situated at the front of the jaw where a crowded condition is common.

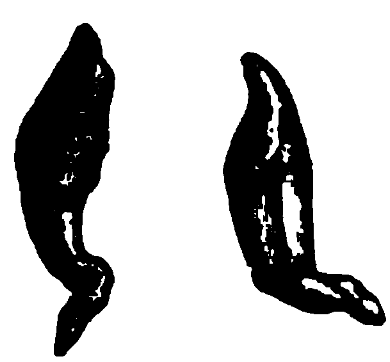
Teeth which have undergone dilaceration are of course easily recognised when the injury affects the tissues of

FIGS. 43 and 44.



the crown, but when the crown is well formed and merely bent at an angle with the root, careful examination is sometimes required to distinguish the case from one in which a well-formed tooth is lying in an abnormal position. The latter case might be amenable to treatment, which would be inapplicable to dilaceration.

FIGS. 45 and 46.

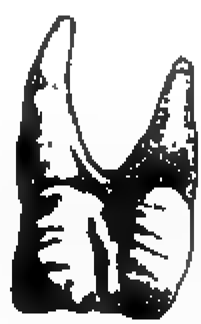


Teeth the subject of dilaceration often present marked bulgings upon either surface close to the neck, which is frequently constricted and well defined; they occasionally display marked mobility under slight pressure, and the distorted root may be in some cases traced by the finger through the alveolar wall. Fig. 43, from Wedl, represents a case of dilaceration or flexion occurring in an upper central incisor, of which a side view is presented. The crown is perfectly developed, but the

root is short and thick and much curved, its apex being directed towards the lips. Fig. 44, from Wedl, shows a lower central incisor the seat of dilaceration. The crown is bent at a right angle to the root, and the cutting edge is directed towards the lips. Figs. 45 and 46, from Wedl, illustrate similar malformations of the roots of upper central incisors.

Gemination, apparently the result of organic union of two neighbouring teeth during development, sometimes occurs. It rarely affects any but incisors, and the union may extend through crown and root, or may affect only a part of the teeth. Blended crowns contain as a rule a common pulp cavity, but in blended roots the chamber is divided or distinct. Gemination does not necessarily give rise to marked deformity in the appearance of the

FIGS. 47, 48, 49 and 50.



teeth. Figs. 47, 48, 49 and 50, from Tomes,* show examples of these malformations.

Supernumerary teeth are frequently met with. They are as a rule easily recognised, being mostly of an irregular conical form, unlike any member of the normal set of teeth. They may occur in any position, but their most common situation is towards the front of the mouth, where they are usually placed irregularly among the other teeth. Sometimes a supernumerary tooth is

* "A System of Dental Surgery," 4th Edition, 1897.

symmetrical in form, and placed within the dental arch, and hardly distinguishable from its neighbours—an individual in this way possessing an extra or supplemental

FIGS. 51, 52 and 53.

incisor or canine. Figs. 51, 52 and 53, from Salter, illustrate common types of supernumerary teeth. Fig. 54, from Salter, and fig. 55, from the *Transactions of the Odontological Society*, show supernumerary teeth in position in the upper jaw. Other examples are illustrated in the chapter on "Irregularities."

FIG. 54.

Mr. Bland Sutton believes that the origin of geminated teeth, and of some supernumerary teeth, is explicable on the theory that a dental germ or papilla may occasionally bifurcate, but it does not necessarily follow that two distinct teeth arise in consequence of the dichotomy, for during development the two teeth may fuse and produce gemination. This opinion is supported by the fact that dichotomy of a similar kind is to be

observed in the feathers of some species of birds, and has been occasionally noticed in the hairs of man. The dichotomy is not always equal or complete. In the case

FIG. 55.

of teeth when dichotomy is equal and complete the teeth are as like each other as twins, and difficulty arises as to which shall be regarded as supernumerary.

In such a specimen as fig. 50 the dichotomy of the papilla was equal, but in the case represented in fig. 56, from Tomes, a lower molar, with a small tooth projecting from its side, the dichotomy was unequal, and in

FIGS. 56 and 57.

both specimens probably only partial. Complete and unequal dichotomy would produce the small mis-shapen supernumerary teeth such as above described and illustrated.

Other abnormal teeth, presenting several forms, varying between so-called warty teeth, studded with nodules of enamel, and monstrous teeth, mere shapeless

masses of dental tissue, must be considered identical with the morbid growths termed odontomes, the nature of which is more fully discussed in a later chapter.*

The specimen shown in fig. 57, described by Mr. Bland Sutton, throws some light upon this subject. This tooth was removed from a lad aged nineteen years; it was situated in front of the right upper bicuspid, displacing the lateral incisor and canine, so as to occupy their position in the dental arch. It has no root, and appears to consist merely of a crown and neck, but the crown bristles with cusps, and as many as nine distinct enamel-covered eminences can be detected. The appearance of the specimen is as though a group of supernumerary teeth had become confluent. Had such a tooth been dislodged from a swelling below the gum, it would have been described as an odontome, and regarded as an odontome which had cut the gum and taken rank with the normal teeth. Mr. Bland Sutton has pointed out that odontomes resemble teeth in this way—for a time during their development they remain hidden below the mucous membrane, and give no evidence (or very little) of their existence. To this condition succeeds an eruptive stage, when perhaps suppuration, with the constitutional disturbance dependent thereon, draw attention to the part. If this view be correct, this remarkable structure must be regarded as an odontome which has cut the gum and taken a position in the dental series. This specimen is further interesting in that it consists of a conglomeration of denticles. Mr. Sutton has urged that those remarkable cases in which denticles have from time to time been erupted from a tumour connected with the jaw should be classed as odontomes. It is easy to imagine that if the cusps of this odontome had remained

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* See chapter on Morbid Growths.

distinct and had each been separately erupted, they would have been called supernumerary teeth. Indeed, many of the cusps can be easily detached from the main mass. This strange specimen serves to bridge the gap between what have been called compound follicular cysts and composite odontomes.

Treatment of Abnormal and Supernumerary Teeth.—The sole treatment which can be requisite in any variety of the above described abnormalities is extraction of the tooth, an operation which is of course not called for unless the faulty tooth be unsightly, a cause of deformity, or of disease.

IRREGULARITIES OF THE TEETH.

Under the denomination of "Irregularities of the Teeth," are usually classed a considerable variety of disfigurements and deformities, of which the teeth constitute the most salient feature. These cases may, to facilitate description, be divided roughly into two great classes:—1st, those in which teeth occupy abnormal positions in well-formed jaws; 2nd, those associated with malformation, either of the alveolar border or of the body of the jaw.

The first class of irregularities rarely occurs in the deciduous set, for the reason that in this case a chief cause of irregularity—obstruction by preceding teeth—is absent. Irregularities of the temporary teeth of the first class, whatever their character, are, however, of little practical importance, since the teeth are shed in early life, and the deformities do not call for treatment. Instances of the second class in the infant, although seldom manifest to casual observation, are often perceptible on careful examination, especially when the deformity affects the jaw generally. Children are but rarely brought to the dentist before commencement of the second dentition, except for treatment of decay of the temporary set; but when the opportunity for observation presents itself, it is often possible for the dentist to recognise and call attention to local conditions

which may be conducive to deformity, or may have already begun to influence evilly the development of the jaws.

Irregularities of the First Class.—It was explained in a previous chapter that, during the process of eruption, the teeth are not closely embraced by bone, and that it is not until some time after the crowns have fully emerged from the wide orifices of the crypts that the alveoli become fully formed, and invest closely the necks and roots of the teeth. During this stage of

FIG. 58.

growth, when the advancing teeth are surrounded only by soft, readily yielding tissues, any slight obstacle to their progress suffices to deflect them from their proper direction, and to retain them in a wrong position. The most frequent of such obstacles consist of temporary teeth, or decayed portions of temporary teeth, which have retained their places, after the time at which they

ought to have been cast off. Supernumerary teeth, also, form a frequent cause of irregularity. The most

FIG. 59.

common example of the first class of irregularity, is shown in fig. 58, where the permanent incisors of the

FIG. 60.

Front view of upper jaw of girl. Æt 12½.
A. Temporary canine. B. Supernumerary tooth.
C. Permanent canine.

upper jaw are seen to occupy a posterior position, owing to the persistence of the temporary teeth. A corresponding condition occurring in the lower jaw, is shown in fig. 59. By similar causes teeth may be rotated upon their axes, crowded together so as to overlap, or deflected in almost any direction.

Figs. 54 and 55 show supernumerary teeth interfering with the regularity of upper incisors. Fig. 60 shows a supernumerary tooth placed in the middle line of the upper jaw. Fig. 61, from a neglected mouth—patient æt. 39—exhibits a central incisor twisted across the

Fig. 61.

alveolus, and prevented from fully emerging by a large supernumerary tooth holding the place of the distorted incisor.

Other causes of this class of irregularities are to be traced to injuries, which may be due to blows upon the mouth, or may be inflicted during untimely extraction of temporary teeth. Then again, inflammation and alveolar abscess connected with a temporary tooth may cause displacement of the developing permanent successor; whilst lastly, many cases of simple displacement of one or more teeth in well-formed jaws can only be ascribed to remote causes acting during development.

Some in the latter category are undoubtedly hereditary —malposition of one or more in a set of teeth forming often a characteristic trait common to several members of a family. But, in frequent instances, the causation of irregularities of the class under discussion is, it must be

Fig. 62.

acknowledged, as difficult or impossible to discover as that of total displacement of teeth buried within the bone, described and illustrated in a previous chapter.

Figs. 62 and 63 illustrate the typical variety of irregularity ultimately resulting from unchecked progress of

Fig. 63.

the condition shown in fig. 58. Upper front teeth fully erupted inside the normal line pass on closure of the jaws within instead of without the lower incisors, and the teeth being held in malposition by the bite,* a deformity is produced, which can only be overcome by the

* The arrangement of the upper and lower teeth when in completely close contact is termed the "bite."

mechanical treatment presently to be described. Fig. 64, from Quinby,* illustrates general irregularity of

Fig. 64.

incisors and bicuspids. Fig. 65, from Salter,† shows a not uncommon example of displacement of the upper

Fig. 65

canines, which appear within the dental arch and

* Notes on Dental Practice. 1883.   † Dental Surgery. 1874.

posterior to the persistent temporary canines which hold their places. Figs. 66, 67 and 68, the latter from

FIG. 66.

Quinby, show typical irregularities of upper canine and bicuspid. Other examples of this first class of irregu-

FIG. 67.

larities are shown in fig. 101, in figs. 95, 97 and 98 from Quinby, figs. 102 and 104 from Mason,* and in fig. 106 from Talbot.†

A very fruitful source of irregularity is untimely extraction of temporary teeth, and therefore the first thing to

* Trans. Odont. Soc., Vol. 5. † Irregularities of the Teeth, 1888.

be avoided by the young practitioner is unnecessary interference of this kind. It is very easy to sweep away temporary teeth and to produce a transient improvement in appearance; but it may be laid down as a rule subject to rare exceptions that it is extremely bad practice to extract any temporary tooth for the cure of irregularity unless it be a direct cause of displacement, or form an evident obstacle to the regular advance of its proper permanent successor. During the progress of second dentition, in most instances a child's mouth necessarily presents a more or less unsightly appearance, and the parents, over anxious and ready to imagine that every

FIG. 68.

passing irregularity may become a permanent deformity, will often urge that treatment should be commenced. Clear explanation of the nature of the case, and of the advantage either of delay or of total non-interference when one or other of these may be the proper course, will bring the young practitioner in the end more credit and profit than he could derive from any less ingenuous line of conduct involving the wanton infliction of unnecessary pain and injury upon the patient. Each tooth ought to be left until the last moment at which its presence can be safely allowed. Absorption of the roots progresses rapidly from week to week as the time

approaches for shedding of the teeth. It is both right and expedient to spare a child unnecessary pain and terror. To push or pick from its weak attachment the crown of a temporary tooth of which the roots are completely absorbed need neither excite fear nor give appreciable pain; both of these are likely when the use of instruments becomes necessary.

The evils as well as the benefits which may arise from premature removal of temporary teeth will be perhaps brought out more clearly by examination of some particular instances.

In the case shown in fig. 58 it would be right and expedient to extract the temporary central incisors even if still very firm, immediately the eruption of their permanent successors were impending; but the like haste would be by no means called for in a similar condition affecting the lower jaw seen in fig. 59. In the one case delay might lead to an irregularity incapable of spontaneous cure (fig. 62); in the other case the normal position of the lower incisors being within the uppers, the obstructing temporary teeth might with safety be left for a much longer period with the certainty that in the end the displaced teeth would assume the correct position.

In neither of these cases would extraction of the temporary laterals be expedient for the purpose of increasing the space available for the forward movement of the centrals. Whatever relief might be given to the centrals, the effect of this operation would probably in the end be to give rise to more serious irregularity of the laterals, which deprived of room, would be forced backward or seriously deflected in some other direction.

Untimely extraction of the temporary canines is usually a very injurious procedure. The operation is one which is very often improperly performed at the

urgent request of parents who, whilst ignorant of the evils which result from ill-timed interference, are anxious to avert a deformity—crowding and overlapping of the central and lateral incisors from lack of space—which may seem imminent. The first bicuspids come into place from one to five years before the permanent canines. The effect of removing temporary canines soon after the appearance of the permanent laterals to relieve what is often only transient crowding of these and the central incisors, is to allow the first bicuspids to move gradually forward until they come into contact with the permanent laterals, thus occupying the places which should be filled later on by the permanent canines. This happens in almost every such case but with more certainty in undersized jaws, and here in the end the mischief is commonly most serious. The ultimate result is that the permanent canines being excluded from their proper places become erupted externally more or less high over the position through which they ought to descend, and in consequence occasionally assume so faulty a direction that their regulation becomes difficult, or even their extraction becomes necessary. In the lower jaw a corresponding condition may be in the same way induced. To make room after this mismanagement, sacrifice of permanent teeth will be called for, which might perhaps have been avoided had the temporary canines been preserved for their full period. In the majority of well-managed cases where, owing to lack of space, there is on completion of dentition merely general crowding, and no other irregularity, the only treatment called for is, as a rule, extraction of a first permanent molar or bicuspid at each side as soon as the second molars are fully erupted. A case of this kind will usually right itself within a few months to a year by the gradual

spreading of the whole set after room is afforded. On the other hand, in instances aggravated by untimely extraction of the temporary canines, long mechanical treatment may become necessary, unless instead of the molars the first bicuspids are removed ; but if the bicuspids, as so often happens, are sound and the molars badly decayed, the last named procedure can hardly be entertained. The extraction of permanent canines unless they are hopelessly malplaced is unjustifiable, for these teeth are relatively among the strongest of the set, and they contribute much to the character and symmetry of the front of the mouth. Mechanical treatment—long and tedious—which might have been avoided, thus becomes often, in these cases, necessary not only to force the canines in the desired direction, but as a preliminary step to make room by pushing back the bicuspids which may have besides become locked in their too forward position by the bite. It is, therefore, clearly preferable to allow a continuance of considerable irregularity of the permanent incisors for a time rather than relieve it by removal of the temporary canines ; for in any case in which the irregularity might be likely to remain after childhood it would not be cured by the operation, but on the contrary, the general condition of the set must be in the end made worse. Cases of an opposite character, in which evidently nothing but good could arise from removal of the temporary canines are exemplified in fig. 65.

Too early extraction of the temporary molars gives rise to evils similar to those just described ; for then the first permanent molars move forward as they are erupted and encroach upon the space which should be occupied by the bicuspids, which appear later. This no doubt, besides causing displacement of the bicuspids, sometimes leads to crowding of the whole front range of teeth.

There seems good reason to believe that during untimely extraction of a temporary molar the bicuspid which lies in its crypt within the roots may be displaced. In this way the irregularity illustrated in fig. 68 might be accounted for. It has also been suggested that after premature extraction of temporary teeth the alveolus becomes filled up with dense osseous tissue, through which the permanent tooth, when the period of its eruption arrives, cannot penetrate and thus becomes deflected through the more yielding internal or external alveolar plate.

It very often happens that children's teeth are neglected until the appearance of disfigurement from irregularity, at the commencement of second dentition, draws attention to them. By this time, in such cases, many of the temporary teeth may have been partly destroyed by decay, and their remains—hollow, pulpless crowns, and more or less necrosed roots—may be found along the alveolar border. It is not uncommon to see the crowns of bicuspids emerging through the hollowed shells of temporary molars, the roots of which have been absorbed; or fragments of broken-down crowns and spicula of necrosed roots may be wedged among and around the emerging crowns of the permanent set. This condition frequently gives rise to general irregularity, mostly of slight transient nature. Fig. 64 represents the type of irregularity resulting from the cause in question.

Although it may be necessary to extract decayed temporary teeth before their time for the relief of disease, the same principle applies to them as to healthy teeth in relation to irregularity, and they must not be removed as a rule until the period at which they ought normally to be shed. Temporary teeth ought to be watched as carefully as permanent, and preserved by stopping when

decay appears. The physiological process of absorption described in a previous chapter, by which the roots of deciduous teeth are gradually removed, ceases on the death of a root. The cessation of the physiological process is, however, usually followed by absorption such as mostly affects dead teeth and bone, but this is slow and often ineffectual. Necrosed teeth and roots are therefore more than living teeth likely to be retained and form obstacles to the proper progress of their successors, and on this account they call for greater watchfulness, and unless exceptional conditions prevail they must not be allowed to remain long after the normal period of shedding.

All the reasons against ill-timed treatment must be kept steadily in view, and yet while uncalled-for interference should be guarded against with the utmost care, there need be no hesitation in extracting temporary teeth, the removal of which is demonstrably necessary for the cure of irregularities. Some of the evils which may arise from persistence of temporary teeth long after the period at which shedding ought to take place, were described under the heading "Retained Temporary Teeth," in the chapter on "Dentition," and to these evils may be added the possibility of a permanent tooth being forced to take a course outwards or inwards through the alveolar wall. It is a somewhat popular belief that the premature extraction of temporary teeth may act as a cause of contraction of the jaw, and thus of subsequent irregularity of the worst kind; hence, as just pointed out, whilst some parents will urge treatment, others will strenuously oppose the performance of the most necessary operations. The belief is refuted by physiological fact as well as by practical experience. The growth of the alveoli of the permanent teeth (as explained on a previous page) goes on quite independently

of the temporary set, and cases are on record in which even after the premature loss of the entire temporary set the jaw attained its normal development and the permanent teeth assumed their proper positions.

A knowledge of the order in which the teeth are erupted and of the characteristics which distinguish the permanent from the temporary set, will prevent the mistake against which it is necessary caution should be exercised, of extracting one of the former instead of one of the latter. An error of this kind is, however, hardly possible, except in the case of incisors and canines. The permanent molars may be known from their position at the posterior extremity of the jaw beyond the range of the temporary teeth; whilst the bicuspids may be easily recognised since no such tooth exists in the deciduous set. The permanent, if present during the persistence of the temporary incisors, will be found in the vast majority of cases behind the teeth which they replace, and their cutting edges are serrated, whilst those of the temporary set by this time are worn smooth. The permanent canines may be distinguished by their great size in comparison with the corresponding temporary teeth, and by their position, which is external and prominent, the root being marked by a vertical projecting ridge on the external alveolar wall. A distinguishing characteristic of all temporary teeth is formed by the ridge-like termination of the enamel at the necks—a formation easily recognisable, as a rule, by passing a fine-pointed dental exploring-probe over the surface. The occasional occurrence of anomalous cases must not, however, be forgotten—cases like that, for example, shown in fig. 65, where the permanent canines have presented themselves within, instead of, as is usual, without the arch. Cases of this kind, although comparatively rare among patients, are relatively frequent in the practice of dentistry. It is

hardly possible they can be mistaken by any practitioner of the least experience, and where doubt exists careful examination of the teeth will reveal their character.

The presence of supernumerary teeth already referred to, forms an occasional complication which must not be overlooked; and a neglected mouth in which numerous temporary teeth also are retained, whilst the crowns of the permanent set are appearing through the gums in various directions, will sometimes need close examination, even by an experienced practitioner, before the real nature of the case can be determined.

A very large proportion of cases of simple irregularity of one or more teeth recover spontaneously in the course of time, when room is afforded by growth of the jaw for the movement of the teeth, if they are not locked in their mal-position by the bite—as, for example, in the cases shown in figs. 62 and 63. The movements of the tongue, the pressure of the lips, and the effects of mastication—all or either of these help to press the teeth in the proper direction to which they indeed tend in their natural growth. Unless, therefore, it be clearly evident that mechanical treatment is unavoidable—that the deformity cannot be mended, or may be aggravated by delay—the teeth are better left until about the twelfth year; or until the period at which the second permanent molars are in place. By this time it will have become possible to decide whether other teeth will need treatment, and whether sacrifice of permanent teeth will be called for to afford room for spreading apart of the set, and if so, upon which the choice should fall; and the preliminary necessary operations having been completed, an instrument may be constructed to act at once upon all those teeth which need mechanical treatment.

A tooth merely deflected in its course, the crown malplaced, but the apex of the root in its natural

position, can, in a majority of even extreme cases, be in time drawn into its proper place. The nature of the case may be determined usually by careful examination, the outline of the root being often sufficiently indicated through the overlaying bone. The possible existence of dilaceration in these instances must be kept in view.

Numerous instances, however, present themselves in which one or more teeth are so far displaced as to preclude the possibility of their reduction by any means to their proper positions. Such instances are specially those in which not only the crown, but the entire root is out of its normal position. For example, an upper canine, being erupted after the lateral incisor and bicuspid are in position, often presents itself external to and prominent over the space between these teeth, which is too narrow to contain it. When the direction of the canine is correct it will in time take its proper place if room be afforded, but should it appear in an oblique direction, and with its root lying at an angle across the alveolar border and the apex far away from its right position, in the direction somewhat roughly indicated in fig. 66, it is unlikely that it could be brought into the desired position, even were mechanical treatment employed. In this case, the root was lying more horizontally than the cut suggests. Another example of irremediable displacement of a canine is shown in fig. 67. The situation of the root is indicated by the " In such cases the extraction of the malplaced is the sole resource. An example of irremediable .cement of a bicuspid—a kind of irregularity which ɔ frequently met with in the case of other teeth is ı in fig. 68 from Quinby.

: main points in the preliminary treatment of ılarities of the first class may be summed up as 's :—

1st. Bearing in mind the cautions above given against indiscriminate and untimely extraction of apparently obstructive temporary teeth, real obstacles, whether formed by temporary or supernumerary teeth, must be removed.

2nd. Unless fixed in mal-position by adjacent permanent teeth or rendered incapable of movement by the bite, irregular teeth ought, after removal of obstacles, to be allowed time to assume spontaneously their normal position, to which when free they always tend.

3rd. Mechanical treatment ought never to be commenced before the full eruption of the second permanent molars, except in such cases as evidently cannot spontaneously recover, or in which after lapse of time no tendency towards improvement is manifested.

The principles of mechanical treatment being the same in all varieties of irregularity, the two classes in this connection are discussed together on later pages.

Irregularities of the Second Class.—Irregularities due to malformation of the alveoli or of the body of the jaws themselves have now to be described. It has been before stated that the normal dental arch is semi-elliptical in shape. The front portion of the figure, containing the incisors, canines and bicuspids, forms an almost perfect semi-circle; whilst the portions containing the molars continue the line backwards at each side. Flattening or contraction of this arch, or abnormal development of any part of it, necessarily give rise to irregularities of the teeth. Relatively or comparatively large teeth often exist in a small jaw, a condition causing crowding and irregularity. The second class of irregularities is often hereditary, a peculiar abnormality in the form of the jaws, which may exist in one or other parent, being in this manner sometimes reproduced in many members of a large family.

It is not necessary to dwell upon the fact that the jaw of civilised races has in course of ages become greatly diminished in size, so that crowding and mal-position of teeth in consequence have become, especially in women, the rule rather than the exception.

Deformity may exist in both maxillæ or in one alone, or may be confined to one side only of the bone. Deformities may be due to injury or other accidental causes.

The almost marvellous manner in which the jaws (like other bones) may be modified in shape, especially during early life, by the continual application of force in one direction, is not uncommonly exemplified in surgical cases.

Fig. 69.

The sequel of extensive burns of the neck occasionally furnishes a striking instance in point. The cicatrix resulting from such an injury has a constant tendency to contract, and unceasingly drawing the chin towards the chest, causes the body of the jaw gradually to curve downwards. In cases from time to time met with, the curvature is so great that the alveoli are completely everted, and the teeth directed outwards, or even downwards. One of these cases is figured in the annexed engraving (fig. 69), taken from Mr. Tomes's work.

Cases like this serve to show that any sufficiently prolonged constant slight strain or tension exercised upon a growing jaw will suffice to modify its form. Causes of analogous kind, although often extremely difficult to trace, may be supposed to account for many common deformities.

The nature of irregularities, associated with malformations of the jaw will be rendered more evident by typical examples. Fig. 70 represents an instance

Fig. 70.

of a common variety; protrusion of the central incisors apparently due to an abnormal outgrowth of the anterior portion of the alveolar processes. This class of deformity is now, for the sake of brevity, usually styled "anterior protrusion." Fig. 71 shows the palatine view of another case of a similar kind. The extent of protrusion in this instance is defined by the lines which mark the position of the lower teeth when closed. Protrusion of the upper front teeth, in a manner resembling that shown in fig. 70, is sometimes apparently due to pressure of the lower incisors, the edges of which impinge posteriorily upon the necks of their upper fellows. This faulty bite seems in some few instances traceable to very early extraction of the first permanent molars, which gives rise to undue approximation of

the jaws. Some cases, to be further discussed presently, are ascribed to mal-development, associated

Fig. 71.

with obstructed nasal respiration, others to thumb-sucking; but a great number of instances can only

Fig. 72.

be set down to faulty development, for which no satisfactory explanation can be given. A somewhat

analogous deformity of the lower jaw depicted in fig. 72 from Talbot, gives rise to projection of the

FIG. 73.

lower beyond the upper front teeth. An individual affected with this deformity is said to be "underhung."

FIG. 74.

The V-shaped or contracted arch, instances of which daily present themselves, is illustrated in fig. 73. This

deformity gives rise to an almost endless variety of displacements of the teeth. The incisors or bicuspids are often forced inwards, and the canines, appearing after these are in position, remain external and prominent. In the saddle-shaped jaw (figs. 74 from Talbot and 75 from *Transactions of The Odontological Society*), which in some ways resemble the V-shaped, the incisors and canines may be prominent, whilst the alveolar region containing the bicuspid and

FIG. 75.

first molars is compressed inwards. The displacements of teeth due to crowding in that class of case in which a relatively small though well-shaped jaw contains disproportionately large teeth (fig. 76 from Quinby), somewhat resemble those occurring in the V-shaped maxilla.

The case shown in Fig. 77 may serve to exemplify and illustrate the condition commonly brought about

where the jaws, although well-shaped, are deficient in width, and the teeth are in consequence crowded, even when, as in this instance, not above the average in size

FIG. 76.

This condition often exists in front ot one or both jaws as soon as the incisors are well in place; and it often

FIG. 77.

needs little experience to enable one to perceive at this epoch of development that the jaw is undersized, and

that the irregularity will increase as dentition advances. In the treatment of this condition a new operation has been introduced within late years. This consists in extracting the first temporary molars and then removing the developing first bicuspids from their crypts beneath. The cases are said then slowly to right themselves without further interference. The general principles which guide the performance of this operation are explained in the chapter on extraction of teeth. The anatomical relations of the parts at about the period when the procedure is carried out are shown in Fig. 32. The depth at which the permanent bicuspid crowns may be found will vary in different cases. They will lie comparatively close to the surface if the temporary molars are ready to be shed; deeper when the roots of the temporary teeth are but little absorbed. The buried crowns may be grasped with an ordinary bicuspid forceps if not deeply placed; if deep, a long narrow-bladed instrument will be required. The facts that the operation must, from a dental point of view, be considered comparatively somewhat severe, and that in most cases it calls for more prolonged anæsthesia than is afforded by nitrous oxide gas have perhaps prevented it from gaining general acceptance. An element of danger must necessarily be introduced where ether or chloroform are administered, and few practitioners or guardians of children will care to encounter that danger for an operation the necessity for which is not imperative. The cases are not, as a rule, difficult to deal with by ordinary methods. In the example illustrated the first bicuspids were first extracted. These were chosen mainly because both were affected by caries; room being thus afforded, the teeth were regulated by the aid of a mechanical apparatus described in a later paragraph.

In a somewhat rarer example of deformity (fig. 78) (Tomes) the molars alone approximate on closure of the jaws, and the incisors remain apart and cannot be brought into contact. This is primarily in consequence of a malformation of the posterior portion of the lower jaw.

These examples will suffice to render manifest the distinction between the two great classes of irregularities, and, for this purpose, little would be gained by

FIG. 78.

multiplying them. In the great majority of cases of malformed alveoli or jaw, it is quite impossible to assign with certainty a cause for the deformity. As no two crania and no two bones of different crania are ever exactly alike, so not less there seems infinite variation to a minute or greater degree in the size and shape of maxillæ in different individuals. Peculiarities are frequently hereditary, and occur in several members of a family through generations. Where a local cause may have existed, the child is very often not brought to the dentist until the cause has

disappeared. Some of these deformities are, however, undoubtedly acquired. Cases of protrusion of the upper front teeth and recession of the lower, as shown in fig.

Fig. 79

70, are often ascribed to the pressure of thumb-sucking in infancy and childhood; but very few instances of

Fig. 80.

the kind in which this cause is demonstrable are met with. It is the exception to find an infant which does not habitually suck its thumb, and if this were a common

cause the deformity in question would much more frequently prevail. The habit, probably, acts injuriously only in cases in which it is prolonged from infancy into childhood, and up to or approaching the end of second dentition. Some few patients who continue "thumb-suckers" until the later years of childhood seem almost unconscious of their habit. In a few cases enquiry has elicited the fact that the child when in a drowsy con-

Fig. 81

dition and composing itself to sleep has habitually put its thumb into the mouth and has gone to sleep in the act of sucking—the thumb remaining there through the night. In such an instance a gradual bending outwards of the alveolar margin of the upper jaw from the pressure might reasonably be expected, whilst at the same time the lower front teeth would be inclined backwards.

The effects of thumb and finger-sucking may be further elucidated by a few authenticated cases. Fig. 79 shows a front view, upper and lower jaws of a boy aged nine. This boy had from infancy practised sucking the right

fore-finger and point of the thumb. The pressure seems mainly to have affected the lower teeth and caused their recession. The boy is the son of a well-known dental surgeon, who, having closely watched the case throughout, has no doubt about the causation. The boy is one of twins. His brother has well-formed, albeit somewhat small jaws. He was operated on at six years for large tonsils and adenoid growths. The rest of the family—father and mother, and girl and boy aged respectively

Fig. 82.

twelve and eight—have uncommonly well-developed maxillæ. The patient has given up the bad habit for about a year, and some small improvement seems already discernible.

The next cases, illustrated in figs. 80, 81 and 82, occurred in the family of a London surgeon—a capable scientific observer. Fig. 80 shows the front view and fig. 81 the palatine view in the case of a child aged seven-and-a-half. This child sucked the first finger of the right hand, and the deformity very markedly in the palatine aspect corresponds to pressure thus resulting. Fig. 82 shows front view in the case of a child aged nine,

a right hand thumb-sucker. The front view of both these cases resembles that of instances due to obstructed nasal respiration; but neither of these children were operated on for that affection.

Both these children were cured of their evil habit within a short time of the ages named. It was soon observed that improvement in the form of the jaws was setting in; and no treatment of any kind was applied. Fig. 83 shows, at the age of seventeen, the mouth of the child depicted

Fig. 83.

in figs. 80 and 81; and fig. 84 exhibits the mouth of the child, shown in fig. 82, when the age of nineteen had been reached. The rest of the family, father and mother and four children presented no anomaly in maxillary development.

These examples of spontaneous cure suggest the reflection as to whether many apparently severe deformities of similar kind, to which mechanical treatment has been applied, would not have become in time remedied by the progress of growth and the action of unaided natural forces.

Deformities resembling, to a greater or less degree, those depicted in figs. 70, 71, 73, 74, 75 and 78, are very commonly found in patients with enlarged tonsils and adenoid growths in the naso-pharynx. These patients breathe with more or less difficulty, and are very often unable to respire at all through the nose. Such children have a characteristic expression. They go always with the lips slightly open and the teeth apart. The muscular tension, the pressure of the

FIG. 84.

tongue, which is mostly kept down on the floor of the mouth with its tip against the incisors, and the unnatural constant slight muscular strain to which the conditions thus give rise are together enough, when prolonged through years, to account for the modification in the shape of the jaw. The ramus seems lengthened, the alveolar margin in front seems deepened, and the crowns of the molars in some examples occupy an unusually high level.

These deformities, particularly the highly-arched palate and the contracted V-shaped alveolar arch, and

protruding upper teeth, have been observed in association with chronic nasal obstruction by numerous surgeons, in whose practice as specialists many such cases occur. Dr. Scanes Spicer* attempts to explain the association on the hypothesis that prolonged disuse during infancy and childhood of the nasal channels for their natural functions, leads to stunted evolution of the nasal framework. The septum and sphenoidal bones partake in this, and fail to push down the palatine processes of the maxillæ, while the rest of the face, including the alveoli, continue to grow. The median line of the hard palate along the attachment of the vomer tends to retain its infantile position. The weight of the lower jaw—which drops to allow of mouth-breathing—acts through the tissues of the cheeks and presses on the superior maxillary alveoli, flattening each curved lateral half, so as to diminish the space available for the eruption of the canines and other teeth, which therefore are compelled to assume irregular positions.

On this subject the latest published observations are those of Mr. Mayo Collier.† He states that, as the consequence of chronic obstruction to nasal respiration, he has seen many instances of children with beautifully formed faces and symmetrical dental arches, become in after-life quite altered. The upper arch has become so distorted that the molar teeth on each side are approximated, whilst the incisor teeth of the upper jaw protrude forwards, and hang in front of the incisor teeth of the lower jaw. The whole upper jaw may become atrophied, the palate highly arched and V-shaped, and the mouth constantly open.

The parents in many of these instances have had remarkably well-formed upper jaws. He states that he can produce the same effect in any young animal by

Trans. Odont. Soc., 1890. † Medical Press, December, 1900.

blocking its nose with cotton wool. He suggests that turbinal atony and hypertrophy in the young and growing subject will act like the piece of wool in the nose of the young animal.

The association of mouth-breathing with high palate, unsymmetrical upper jaw, prominent nose, open mouth, and thin, flattened face, is, he declares, a constant one. He believes that a small increase of pressure from without, constantly applied on the walls of the nasal box, is capable of pushing up the palate, disarranging the upper mandibular arch, and causing general atrophy and an undeveloped condition of the whole upper jaw. Mr. Mayo Collier affirms further that if these cases are taken in an early stage, and the nasal respiration restored, the constant stream of air passing through the nose moulds and expands the upper maxilla, and in time the greater part of the deformity disappears.

In some few cases of underhung jaw, a condition which is mostly innate or hereditary, the deformity is certainly acquired. Several instances have been observed in which children, through constantly practising a trick of thrusting forward the lower jaw, had caused, in time, the lower incisors and canines to slope outwards and the corresponding upper teeth backwards until at length the characteristic unnatural bite was produced. This condition is more easily produced in patients who have been deprived prematurely of the first permanent molars, and in whom the jaws have become in consequence unduly approximated. In one case which was treated, and which was very intractable, relapsing over and over again, the patient, a girl, at the commencement of second dentition, was affected for many months with spasmodic twitchings of the muscles of the face and jaws with constant jerking forward of the chin. Although this case at first looked simple, the upper teeth alone appearing at

fault, the growing bones seemed in the end gradually to become modified in form until at last a true underhung condition was produced. The case was cured at first by merely pushing outwards the upper teeth until they well overlapped the lower, but, after frequent relapses, during many months, it was found that the lower jaw had, in the meantime, really become more prominent, and it was then necessary to extract a tooth from each side of that jaw and draw the front teeth backwards. The bite of the teeth was in the end made natural, and the worst of the disfigurement was overcome, but there

Fig. 85.

remained a decided projection of the chin, no trace of which had been observable before the commencement of the choreic spasms. The appearance of this case when first seen closely resembled that depicted in fig. 85 from Talbot. Where this kind of deformity is acquired it will be usually found that the upper front teeth—as appears in fig. 85—are almost alone affected, the incisors and canines sloping backwards, and the alveolar margins of both jaws being normal; whereas in congenital cases, or cases due to mal-development, the upper front teeth are mostly in good position and the bone of correct shape, the fault seeming to lie mainly

in the lower jaw, which is bodily protruded, owing apparently to undue length of the horizontal ramus. This latter variety is depicted in fig. 72.

It may be presumed that some varieties of malformed maxillæ have a correlation in development with the base of the skull, and this opinion is supported by the fact that these varieties are chiefly confined to the upper jaw. It has been sought particularly to associate the V-shaped and saddle-shaped jaw with congenital idiotcy. There cannot, however, be the least doubt that the V-shaped and saddle-shaped jaw occur in numerous individuals in whom no apparent malformation of any other part of the cranium is to be noticed. On the other hand, examination of great numbers of idiots has not discovered more than a small percentage showing to any marked degree the maxillary peculiarities in question. The jaws in the microcephalic type as might be expected, are often undersized and the teeth crowded; whilst in the macrocephalic they are as frequently prognathous, and with the front teeth prominent and spread apart.

A great deal has been written in late years on the subject of the etiology of abnormal development of the maxillæ leading to irregularities of the teeth; but it can hardly be said that, beyond those stated in previous paragraphs, many facts of either scientific interest or practical importance have been established. A great number of instances, especially those of the small contracted jaw, often associated with highly-civilised types, can only be more or less vaguely ascribed to heredity, race, and evolutionary forces. Another large class may be traced to the mechanical effects of long-continued tension in the muscles, acting directly or indirectly upon the growing jaw. These, as already explained, are most commonly seen in the subjects of nasal obstruction due

to adenoid growths in the naso-pharynx or similar causes. Yet another group are clearly accounted for by the habit of thumb and finger-sucking, when this is continued long after commencement of second dentition. The acquired character of some instances of "under-hung" jaw has been explained; and yet when these and all other examples, possible to explain, have been enumerated, there still remains a large residuum of cases of deformed jaw, upon the causation of which no clear light has hitherto been shed.

The principles upon which mechanical treatment of irregularities are based, being the same in all varieties of deformities, the two classes into which, for descriptive purposes, they have been here divided, may in this regard be discussed together. In entering upon treatment in cases where mechanical aid is called for, it may be necessary in the first place to consider the expediency and desirableness of extracting permanent teeth for the sake of obtaining space; next comes the question of the extraction of such malplaced teeth as are not amenable to mechanical treatment—a question which has been sufficiently discussed in previous paragraphs—and, lastly, there is the construction and application of a suitable apparatus.

Before deciding upon a line of treatment in these cases, unless of the simplest character, it is well to make casts of the mouth, and to study the relations of the teeth in either jaw, as well as the conditions—the bite—when the jaws are closed. The mechanical problem is often rendered much more evident, or distinct, by this means, and the favourable or unfavourable circumstances are often more easily recognisable than is possible by mere examination of the mouth.

With regard to the extraction of permanent teeth *for the sole purpose of affording room,* it has been more than

once stated that the sacrifice of an incisor or canine is rarely necessary or justifiable. Extraction of these teeth in any case of irregularity is only justifiable under the exceptional circumstances which will be presently exemplified and explained. The most durable of the teeth they contribute most, or are most essential, to the symmetry of the dental arch; moreover a tooth may generally be chosen, the removal of which will better serve towards the desired end. The choice as a rule—a rule however subject to several notable exceptions—will fall upon the first molar. This tooth is the most liable to decay, and even in early life is often so extensively carious as to require extraction, or at least is in a condition so defective that it cannot be expected to last many years. After the extraction of a tooth from a crowded jaw the pressure is relieved and the teeth spread equally apart until in a comparatively short time (very rapidly in early life) the space previously occupied by a large tooth becomes obliterated. In most cases to relieve crowding it is desirable to remove a tooth at each side of the jaw. If only one tooth be extracted, the movement of the crowded members takes place towards that side, and the regularity of the dental circle is disturbed.

It is in the highest degree advisable to postpone the extraction of the first molars until the complete eruption of the second molars at about the twelfth year. The first molars, if carious, must be filled and preserved till that period. If they be extracted earlier, as sometimes through neglect becomes unavoidable, it often happens that the second molars incline forwards as they advance, and thus, occupying the place of the extracted teeth, prevent the backward movement of the crowded front teeth, besides deranging the bite and giving rise to other evils already described.

In cases where it becomes necessary to extract a tooth from each side of both jaws, it is, as a rule, advisable to remove antagonising teeth. Fig. 86, from Quinby, exemplifies a difficulty which may arise if this course be not adopted. In the case depicted, a bicuspid has been extracted from the upper, a molar from the lower jaw. The upper molar having lost its opponent has dropped somewhat into the space beneath, and the resulting bite has effectually prevented the movement of the lower teeth.

Exceptional cases sometimes present themselves, in which extraction of a tooth from one side may suffice. These are cases of asymmetrical development, in which deformity is confined to one side alone of the jaw.

Fig. 86.

Should the first molar be free from serious defect, any other back tooth which shows greater signs of decay, or of imperfect structure, may of course be chosen instead. Where doubt exists, the relative liability of the different classes of teeth to decay will largely govern the choice, but other important considerations must not be overlooked. Where the crowding is extreme a tooth smaller than a molar may not afford enough space; on the other hand it must not be forgotten that bicuspids extensively carious are very difficult teeth to preserve. These teeth, when attacked by decay in early life, are most often affected on their mesial or distal surfaces, in a situation where a comparatively small cavity will nearly approach

the pulp and render the insertion of a very permanent stopping exceedingly difficult. On the contrary, the first permanent molar, a large massive tooth, lends itself readily to extensive filling operations, especially when decay has not gone rapidly towards the pulp, and there remains a basis of solid tissue upon which to securely found a stopping. Again, a molar which, although slightly carious, has lasted from the sixth to the twelfth year, may be trusted, if properly filled, to stand for many more; whereas the bicuspid at the twelfth year is a new comer of untried strength, which may show signs of rapid failure after a short time. The peculiarities of the bite will, moreover, make it often evident, not only that more speedy relief to crowding will be afforded by removal of bicuspids than molars, but that in some instances mechanical treatment may be dispensed with, which would have been called for had a more posterior tooth been taken out.

For all these reasons it will be found, in practice, that when removal of bicuspids promises to afford enough room, they may be often sacrificed with more advantage than any other members of the set.

Few things conduce more to the onset and rapid advance of decay than a crowded, irregular condition of the teeth, and when this condition exists the removal of one or two even sound teeth from each jaw has a highly beneficial influence over the future health of the rest of the set, and on this ground alone the operation is often advisable.

The relative liability of different classes of teeth to decay has been ascertained from carefully collected statistics. The first molars, as just stated, are much more often attacked by decay than any others of the teeth; next in this respect come the second molars; after these the second bicuspids; fourthly, the first

bicuspids; fifthly, the lateral incisors; sixthly, the canines; and lastly the central incisors which are less frequently the seat of caries than any other teeth of the set.*

It has been already more than once stated (and the fact cannot be too strongly emphasised) that space having been obtained by the extraction of teeth, Nature may be trusted unaided to effect a cure in a very great number of cases of irregularity, and particularly in those due to crowding alone, in which the general direction of the teeth is good, and where they are not locked in their mal-positions by the bite; but nevertheless in many cases, in any class, mechanical treatment will be necessary if perfect symmetry is required.

It is very rare to meet with or see described any case in which extraction of an incisor or canine, merely for the relief of general crowding, could be justified, but every now and then instances present themselves in which other circumstances combine to render this procedure desirable. For example, a case has lately been treated in which the upper lateral incisors, in a neglected mouth, were, at the age of twelve, so damaged by caries that their crowns were beyond repair, and the crowding in front being extreme, the central incisor crowns had become forced into carious excavations on the mesial surfaces of the laterals. The first permanent molars were also broken down to the level of the gums. These teeth, and also the lateral incisors, were therefore extracted. This gave enough, although not too much, relief, and the space left by the extracted teeth became soon obliterated.

Another case in which upper lateral incisors were removed, is the following:—Fig. 87 displays the palatine aspect of the mouth of the patient at the age of twelve, a

* See chapter on Caries.

front view of whose upper teeth at the age of twelve-and-a-half is shown in fig. 60, on an earlier page. The patient came first under observation at the age of eight; at twelve years, the temporary right central incisor still held its place, although the left permanent central incisor had been erupted at seven years. The case was examined at frequent intervals, but no sign of the missing

Fig. 87.

A B C D

Upper dentition of girl æt. twelve.

A. Temporary canine.
B. Temporary right central incisor.
C. Left permanent central incisor.
D. Left permanent canine.

tooth being discernible (this was before the invention of Röntgen ray photography) it was thought best to wait. The temporary incisor was shed at twelve-and-a-half years, and was immediately succeeded by the supernumerary tooth shown in fig. 60. This tooth was at once extracted. Very shortly after this operation the missing central began to appear, as well as the canine

of that side, the eruption of which also had been retarded, and at the age of fourteen the case appeared as displayed in the photograph, fig. 88. The further treatment in this case consisted in extraction of the lateral incisors, and the application of a regulating apparatus to direct the teeth into the correct position. The reasons for this treatment were as follows:—(1.) To expand the arch,

FIG. 88.

A B C A

Upper dentition of girl, æt. fourteen.
A A. Permanent canines. B & C. Central incisors.
Posteriorly are seen the lateral incisors.

and to force the laterals into place, would have called for extremely prolonged use of regulating plates, with the probable injurious effect upon the teeth associated with such long treatment—a subject explained in a later paragraph. (2.) The expanded upper arch would then have been out of proportion to the lower, which, to make the jaws symmetrical, would also have needed equally

long mechanical treatment. The satisfactory ultimate result of the course adopted is exhibited in fig. 89—the patient's upper jaw at the age of twenty-one, five years after completion of treatment.

A third illustrative case in which a lateral incisor was extracted is shown in fig. 90. This photograph shows the upper jaw at the tenth year. The left central and lateral

FIG. 89.

incisors were slightly, the right lateral extensively carious. The worst damaged lateral was extracted. The right temporary canine which still held its place was shortly shed. Fig. 91 shows the condition of the teeth at the age of fourteen, one year after completion of treatment by mechanical apparatus.

In further exemplification of the circumstances under which sacrifice of a front tooth may become expedient, the following case, in which a central incisor was

extracted, may be here interpolated. It illustrates as well several points in the treatment of irregularities. A young lady, aged fourteen, received a blow in the mouth from a stone, which caused a fracture extending through the crown of the left upper central incisor. It was not until a year later that she was seen, and it was then found that the fracture deeply involved the root, and rendered its preservation impossible; the tooth was

FIG. 90.

A

Upper dentition of girl, æt. ten.

A. Right lateral incisor; extensively carious, afterwards extracted.

therefore extracted. The accompanying cut (fig. 92) shows the appearance of the upper jaw after this operation. There was considerable irregularity of the teeth. The right central and lateral incisors, and the left canine fell considerably beyond the range of the lower teeth on closure of the mouth, whilst the right canine and first molar were displaced backwards, the cusp of the former

locking within the lower teeth. Considering all the circumstances, it was deemed preferable to attempt to regulate the teeth, and to bring about, at the same time, closure of the gap in front, rather than to condemn the patient to wear an artificial tooth. An apparatus of the character to be described in the following pages was accordingly made to exert constant outward pressure on those teeth which were within the normal dental circle, and flat springs of wire were brought round at each side

Fig. 91.

in front, to act in the opposite direction upon the projecting incisors and canine. The next engraving (fig. 93) shows the effect produced after three months of this treatment, and by the exercise of an amount of force, so slight as to give rise throughout to no irritation, beyond a trivial passing tenderness of some of the teeth. The rapid favourable progress of this case was due, to a great extent, to the youth of the patient, and to the

ample room which the loss of the incisor provided for the spreading apart of the crowded teeth, and their movement in the desired directions. The case under this treatment showed in a short time still greater improvement in the arrangement of the teeth.

The rule forbidding extraction of lower incisors admits of occasional rare exceptions. From time to time cases occur in which a single central or lateral becomes gradually forced either completely within or without the dental arch, the rest of the set both above

FIG. 92.

and below being regular and also free from serious decay. This irregularity does not usually develop fully until towards the end of second dentition, before which time it ought not to be interfered with. In some such cases it is justifiable to extract the malplaced tooth, rather than remove two back teeth, which would be the better treatment under other circumstances, particularly if the first molars were seriously decayed.

Regulating Apparatus.—Instruments for the purpose of regulating teeth are constructed to fulfil several objects —to prevent locking together of the teeth of the opposing

jaws on closure of the mouth, and, in accordance with the requirements of the case, to exert such continued pressure or traction on those that are displaced or on the bone, that the teeth may be gradually compelled to assume their normal positions or the alveolar margin slowly modified in form to the desired extent. It has been seen that irregularities vary between the simplest kind—mere slight displacements of growing teeth—and the severest form associated with malformation of the maxilla. It will be understood, therefore, that the effect required to

FIG. 93.

be produced in different cases by mechanical treatment varies also considerably; and it will be perceived likewise that the treatment can be carried out much more rapidly and effectually in the child than in the adult. At the former period of life, when the alveoli are in process of growth, a malplaced tooth can be drawn into position in a short time, and with the exercise of but slight force; whereas, at a later date, the jaw having become consolidated, the treatment becomes long and tedious. The ease with which, if sufficient time be given, a developing bone

may by mechanical means be modified in shape has already been referred to. It will be evident that in the simplest cases an instrument is not required to do much more than guide the developing tooth in the desired direction, whilst in the more difficult it will be necessary to keep up such pressure as shall cause absorption of the bone which opposes the movement of the tooth. To give rise to absorption by continued pressure, it is well known, is not difficult either in the jaw or in other bones. The precaution must be taken in dental cases not to cause irritation sufficient to pass into destructive inflammation. Some amount of congestion or, perhaps, even inflammation of the slightest extent must necessarily accompany absorption, but it is not difficult to arrange the apparatus to exert with great nicety any amount of force required without exciting inflammation of undesirable severity. The more slowly the teeth are moved the less danger will there be of mischief arising. It is only experience in each case that can determine the degree of force which may be safely applied, and it is well, therefore, to commence always with a small amount, and gradually increase it, keeping the case under close observation where uncertainty exists.

That the movement of teeth under the influence of pressure must be accompanied in some instances by absorption of bone seems beyond doubt, but, from the fact that the opportunity for post-mortem examination never presents itself during the treatment of these cases, the exact mode in which the changes in the tissues are effected cannot be ascertained; and, for a similar reason, it is impossible to explain the well-known circumstance that even after the absorption of bone has been apparently induced, and the teeth have taken the desired positions, they tend invariably to fall back into their former situation unless naturally fixed by antagonism with the teeth of

the opposing jaw, or mechanically retained for a considerable time by an instrument constructed for the purpose. Thus in the cases shown on previous pages, in figs. 62 and 63, the treatment might cease safely so soon as the upper teeth, being sufficiently far erupted to well overlap the lowers, had been pushed into their normal position where they fall in front of the corresponding lower teeth whenever the jaws are closed; whilst in such a case as depicted in fig. 70, if, after the reduction of the deformity, treatment were discontinued, a relapse would certainly take place, the teeth falling back into their old positions with a rapidity corresponding to that with which they had been made to assume the new. In all such cases as these, after the irregularity is cured, a plate must be arranged to hold the teeth in their new positions, and must be worn from six months to two years, according to the age of the patient and the severity of the deformity.

It must be by no means understood because mechanical treatment of irregularities is most effectually carried out in early life, that, therefore, treatment should be commenced in every case as soon as the deformity becomes recognisable. On the contrary, it is found, in practice, that the only cases in any class in which it is expedient to commence mechanical treatment, at a period before the permanent canines and second permanent molars are well in place, are those in which the deformity must evidently become either confirmed or aggravated by delay. Examples of the most common variety of this class of case is shown in figs. 62, 63, 72 and 85. Upper or lower teeth, as in these instances, once locking improperly within or without, as the case may be, on closure of the jaws, obviously can never assume their proper position without mechanical treatment. The inexpediency of too early treatment even in cases like this

has been spoken of on an earlier page. There is besides this last class hardly any other mal-position which front teeth can take during eruption which will not probably improve, or become spontaneously cured in the natural process of development as time goes on. The movements of the lips and of the tongue, the pressure of adjacent teeth and the force of mastication—either or all of these usually suffice to direct the teeth towards their normal positions to which also they naturally incline. On the other hand misplaced teeth pushed too early and quickly into position by mechanical treatment, will quickly relapse in most instances, unless a retaining plate be worn for a period. Spontaneous cure is more certain and permanent than cure by art, and, therefore, should have fair play whenever its manifestation becomes recognisable. Similar remarks apply with even greater force to cases where deformity is due to mal-development or acquired deformity of the jaw. The cases in this category must be extremely rare in which it would be expedient to apply mechanical treatment before the period named. The examples of spontaneous recovery in cases due to "thumb-sucking," given on previous pages, may serve to enforce this view. This view will be further enforced by the observations on the effects of nasal obstruction in a preceding paragraph; and it must be laid down as a general rule that, in all cases of "mouth-breathing," in which a possible causal connection with deformity of the jaws may exist, treatment should be first directed to restoration of unimpeded natural respiration, and that after this treatment, particularly in young subjects, sufficient time should be allowed, before application of mechanical apparatus, to judge of the likelihood of spontaneous cure. To these cases the dental surgeon has frequently the opportunity of directing the attention of parents at their earliest stage.

The simplest form of regulating apparatus consists of a plate accurately adapted to the teeth and gums, the crowns of the molars being covered, when desirable, with a sufficient thickness to prevent the upper and lower front teeth from meeting. A fixed point is thus provided to which screws, springs, or levers, elastic bands, or wedges of wood, may be attached to act upon the teeth in any desired direction. It is of the first importance that the plate really form a fixed point perfectly rigid, and distributing its strain as equally as possible over the teeth and gums which it envelops. The material of which the plate is constructed may be either metal, or vulcanized india-rubber or metal and vulcanite combined. Vulcanite has some great advantages over metal. It is easier to make it firm in the mouth. If a perfect model be taken—and this is of prime importance—and the plate vulcanized upon it, the accuracy of the fit alone in most instances will suffice to fix it in the mouth. Additional rigidity may be obtained by slightly paring the model before vulcanizing at the necks of the temporary molars if these are in place, and after this it is never necessary to attach the plate by ligatures or clasps, an expedient which must be adopted frequently where metal alone is used. Vulcanite again affords a more congenial surface for mastication than metal, and is less liable to chafe the surface and injure the enamel of the teeth with which it is in contact.*

Of whatever material the plate is constructed it ought to be removed at intervals, as frequent as possible, for the purpose of thoroughly cleansing it as well as the crowns of the teeth which it envelops. The plate causes accumulation of particles of food over the surfaces of the

* The details of impression-taking and the technicalities of dental mechanics proper, a knowledge of which is needed by every dentist, do not fall within the scope of this manual.

teeth which it covers. These particles, if allowed to remain, speedily decompose, and thus give rise to decay of the teeth. A tooth-powder, such as prescribed on a later page, may be used with advantage during wearing of regulating plates; and the teeth may in addition be brushed with an antiseptic lotion, with which the mouth can also be frequently rinsed during the time the plate is in position.

Whilst it is not likely that even ill-made teeth would be seriously injured by a regulating instrument worn with due precautions only for a short period, it must not be forgotten that in cases where teeth are of inferior structure, and particularly in unhealthy children in whom the secretions of the mouth are habitually vitiated, prolonged wearing of apparatus even when great pains are taken to keep the parts clean and aseptic, will result in most cases in some injury to the teeth. Caries may probably be started in delicate teeth on surfaces which become only to a slight degree abraded by friction of an instrument. Patches of defective enamel may be further weakened, dissolved, and even disintegrated by weak acid which is formed by decomposing adherent *débris* during the daily periods, however short, through which the plate must be left in position. Too much stress can hardly be laid upon this point. Cases are constantly met with in which, after prolonged careless use of regulating plates, many, if not all of the teeth, are seriously damaged by decay; and in which the disfigurement caused by necessary fillings, equals that to which the irregularity originally gave rise. In some cases early loss of teeth with necessity for artificial substitutes forms the final result. Treatment also often becomes intolerable after a time to delicate or fretful children. All these considerations should be put plainly before the guardians of children before treatment is begun, and the advantages

of regulating the teeth must be balanced against the discomfort of the process and the injury which long continued treatment may inflict. In cases where relapse is certain, unless treatment be long continued, nothing is more disappointing than to have to give it up when the deformity has already somewhat yielded. All these circumstances must be borne in mind; otherwise, in the end these cases will in no sense of the word repay either patient or practitioner.

Fig. 94.

To make the character of regulating instruments clearly understood, the description of cases may suffice. Fig. 94 gives the palatal view of the instrument employed in the regulation of the case represented in fig. 62. This was an irregularity of a simple kind, the upper incisors being displaced backwards, and held in mal-position by the lower teeth. The vulcanite plate covering the molars kept the jaws sufficiently apart to prevent the front teeth from meeting, and the obstacle

to forward movement of the teeth being in this way removed, but a slight amount of pressure was required

FIG. 95.

to force them into right position. The pressure was obtained by wedges of compressed hickory, fixed in a

FIG. 96.

chamber in the vulcanite behind and in contact with the irregular teeth. The moisture of the mouth caused the

wood to expand and in expanding to push the teeth slowly forward. The wood was renewed by larger

Fig. 97.

pieces at intervals of a few days as the cure progressed, until the teeth having been driven sufficiently outward the patient was dismissed.

Fig. 98.

A similar effect may be produced by a metal spring instead of a wedge of wood, and indeed this is by some

considered the preferable mode. The spring is more cleanly, more certain, and its pressure is more easily controlled and adjusted. Springs may be made of gold or of pianoforte wire. The difficulty in obtaining much force from gold wire, owing to the unconquerable softness of the metal, even when alloyed for hardness, has led in late years to the introduction of steel pianoforte wire for springs for use in cases where greater continuous force is called for. It possesses the qualities

Fig. 99.

of elasticity and strength to a high degree, and is made in several thicknesses, which adapt it very well for the purpose. Plates with springs are shown in figs. 95, 96 and 97. Fig. 98, from a case of Mr. Quinby's, shows combined action of a spring directed upon a projecting lateral, and a screw exercising traction upon a malplaced canine. The arm of the screw ending in a hook was prevented from slipping by a small pit cut in the canine in which the point lodged. This pit was, on

completion of the cure, filled with gold. The canine in this case readily yielded to treatment, although its crown lay so far from the proper position, and although the patient had long passed the most favourable age of childhood. This case illustrates the great range through which a deflected tooth may be made to move when the apex of the root lies in normal position. It seems evident that to regulate this canine would have been

Fig. 100.

impossible had the whole root been displaced to the same degree as the crown.

The instrument used to regulate the case shown in fig. 77 is exhibited in position in fig. 99. This consists of the usual vulcanite frame carrying wires round the front to exert traction backwards on the prominent teeth; pressure forwards on the central incisors is kept up by compressed hickory wedges behind those teeth. The plate is brought well over the tuberosities of the jaw—a point

which ought, when possible, always to be attended to where rigidity is desired. This case is still (December, 1900) under treatment. Fig. 100 shows the progress made after six months use of the instrument.

The next case is of a different character. The irregularity here consists of rotation of a central incisor on its axis. It was probably of congenital or developmental origin. This is the only possible explanation of the causation of cases in which, where no obstacle to the

FIG. 101.

normal progress of a tooth has existed, it yet assumes a faulty position. The instrument with which it was treated is shown in position in fig. 101. By this time the cure was well advanced. The instrument consisted of a vulcanite frame from which there proceeded flat springs of gold wire so arranged that their free extremities kept up constant pressure on the mesial and distal margins of the incisor. In this way the distorted tooth was compelled gradually to revolve, and the

deformity was in time entirely removed. Fig. 102, from Mason, illustrates yet another method of treating these irregularities. A plate is fitted to the mouth, backing the twisted incisors and carrying screws to act upon the inverted angles, whilst a metal bar passing round in front, and pressing upon the prominent surfaces, causes the teeth to revolve instead of move forward. Fig. 97, from Quinby, shows a plate with springs, acting at once upon a twisted central and a misplaced lateral incisor; and fig. 96, from the same

Fig. 102.

work, represents the simple apparatus—vulcanite frame and metal springs—used in the treatment of the case shown in fig. 64.

Cases, in which the teeth are merely turned in their sockets, are treated by some practitioners by an operation which has been called "actual torsion." This operation is performed by seizing each tooth firmly with a pair of forceps, and slowly and deliberately turning it until reduced to its proper position. By this means it is

believed that the alveolar wall may be made to yield, and the tooth turned without permanent severance of its vascular connections, or injury to its vitality. The forceps ought to be specially constructed with broad flat blades lined with leather, or better with lead, so as to avoid crushing the tooth or damaging the enamel. A plate previously prepared must be in readiness for insertion immediately after the operation, and must be worn for some few months to retain the teeth in the new position. The subjects of this operation

FIG. 103.

should be young children in good general health, and an anæsthetic ought of course to be used. There must obviously exist, after the operation of "actual torsion," great danger of inflammation, perhaps involving the loss of the tooth, but such untoward results are stated to be, in well-chosen cases, rare. It must not be forgotten that in a dislocated tooth, whether the movement be made by accident or design, and whether or not the tooth has never been actually dislodged from its socket, death of the pulp sooner or later often supervenes. This

may not show itself for months or even years, until occurrence of inflammatory symptoms, followed by alveolar abscess over a tooth perfectly free from decay, calls attention to the previous history of injury to, or rupture of, the vascular supply of the pulp. The advantage of "actual torsion" consists in the rapidity with which a cure is accomplished, but in proposing the operation it must be borne in mind that it involves unquestionably a serious risk of loss of the tooth, whilst

FIG. 104.

the desired effect can be produced with certainty by other means, without any danger whatever.

Cases similar to that shown in fig. 70 may be treated by an instrument such as illustrated in fig. 103. From a vulcanite frame extend on either side flat gold wires, made to terminate in front of the canine teeth, and each has affixed at its extremity a small gold stud or hook. An elastic band stretched between these hooks over the faces of the protruding teeth affords the pressure necessary to reduce them in time to their proper position. The same effect may be produced equally well by means

of elastic bands passed over the teeth, and attached behind to the surface of the plate, but this method sometimes causes discomfort by interfering with the movements of the tongue, or with the lower teeth during mastication. An apparatus of this kind is depicted in fig. 104, from Mason. The plate is of metal. The projecting central incisors are acted upon by elastic ligatures attached to a stud on the lingual surface of the plate. The lateral incisors in this case being displaced

FIG. 105.

backwards, are forced in the desired direction by screws passing through the plate, and pressing upon their posterior surface. Plates of this kind furnished with an elastic band (fig. 103), acting at once upon more than two teeth, cannot be recommended for any but slight cases, and they are always somewhat objectionable from their uncleanliness. They have mostly been given up in favour of such apparatus as shown in fig. 105, from Quinby. In this apparatus the bands are metal, and the force is obtained by screws which are tightened

at frequent intervals. Screws may be used either for drawing or pushing, and a plate performing both of these operations at once is shown in fig. 106, from Talbot. The traction is effected through a ligature, the propulsion by direct action of the screw on the malplaced tooth.

Elastic (india-rubber) bands, which often furnish useful means of applying traction in conjunction with a plate

FIG. 106.

may in occasional cases be used alone to draw the crown of a tooth into good position ; but they need caution and watchfulness. It is difficult to get a fixed point without ligaturing one end of the band to several teeth ; and difficult to secure the other end in place over the crown to be acted upon. The bands tend to slip along the neck of the tooth beneath the gum, and it is impossible to keep them clean when in position. They give rise to

irritation, pain, and inflammation; and carelessly used they occasionally lead to the loss of a tooth. For these reasons when rubber bands alone are used the patient must as a rule be seen daily.

In cases where six to eight front teeth are to be drawn backwards it is best to commence with the more posterior teeth and get them into proper position before acting upon the front. It is very difficult, if not impossible, to fix a plate securely enough to stand the strain involved in traction on so large a number at once. Besides this the operation always causes considerable irritation, with swelling of the gums behind the teeth, and this may probably become so extensive as to interfere seriously with treatment if too much is attempted at the same time.

Protrusion of the upper incisors in some cases is, as previously explained, clearly due to abnormal development of the lower jaw, whereby the lower incisors in biting impinge on the posterior surfaces of the upper teeth at their necks in such a direction as to force the latter outwards. In such cases it is well to commence treatment by permanently preventing the pressure. This is to be accomplished by means of a plate fitted behind the upper teeth to receive the impact of the lower incisors, whilst at the same time the molars are left uncovered. The latter teeth are thus kept apart, and in young subjects, under this treatment, they gradually rise, until they articulate again with their opponents. By the time this is accomplished the lower incisors which have been meanwhile prevented by the plate from advancing, no longer impinge behind the upper teeth, and these may then be acted upon and drawn inwards with comparative rapidity and ease. Cases associated with protrusion of the lower jaw must frequently be treated first by drawing back the lower front teeth; and, preliminary to this, it will often be

found necessary to extract a tooth at either side to make room for the movement. These are cases in which bicuspids may often be sacrificed with greater advantage to treatment than any other tooth.

By contrivances similar in action to those already described, the entire alveolar border of the jaw may be modified in form. For instance, in the contracted or V-shaped palate, an apparatus may be made to maintain equal pressure from within outwards along the aveolar margin of the jaw, until in time the required expansion of the arch could be accomplished. Perhaps the simplest apparatus for this purpose is that devised by Mr. Coffin (fig. 107). It consists of a perfectly fitting vulcanite

FIG. 107.

frame, capping the molars and covering the palate. The completed frame is divided by the saw into two equal parts along the central line of the palate. The halves are then connected by a spring of pianoforte wire. The spring is in shape like the letter W, and has its free ends attached one to each half of the divided plate, upon which it closely lies. The spring can be adjusted so as to exert with great nicety the slight outward pressure, which being sufficiently prolonged, is enough gradually to cause the needed expansion of the arch.

Expansion plates—as these instruments are called—are obviously intended chiefly for treatment of V-shaped and saddle-shaped jaws, and other cases where there is lateral flattening or compression of the alveolar borders. The deformity in a great majority of cases affects the upper jaw alone; the bicuspids and molars, and even the canines, in some instances, falling on closure more or less within instead of without the line of the lower teeth. In suitable cases of this character expansion answers well, more particularly in that the teeth when pushed

FIG. 108.

sufficiently outwards are prevented by the bite from relapsing. The question of obtaining space by extraction of teeth, will have been of course first decided after careful study of the models, and in a considerable proportion of these cases room may be made by the treatment for all the teeth without sacrifice of any.

In deformities of this type, affecting the lower as well as the upper jaw, the same treatment, in well-chosen cases, may be attempted. A typical case, upper and lower jaw from the same patient, is depicted in figs. 108

and 109, from Talbot. The coil spring, the invention of Dr. Talbot, with which these plates is furnished, is an admirable contrivance, not only for keeping uniform constant pressure through means of an expansion plate, but also for acting upon single teeth. For the latter purpose one end of the spring is secured to a plate, the other being either made to act directly upon the crown, or to exert force indirectly through a ligature or lever affixed to the irregular tooth in accordance with the design to

Fig. 109.

be achieved. For example, such a spring acting directly upon a tooth will push it in any desired direction; will exert drawing force if secured to a ligature; or pressing upon the extremity of a lever (a bar or collar) affixed to the crown, will effect rotation of a tooth with great ease and certainty. The force of these springs may be regulated with much nicety by merely bending the arms outwards or inwards. These springs, in different sizes of wire, are supplied by dental instrument makers.

The jack-screw and modifications of it (fig. 106) form a powerful means of applying pressure effectually across the jaw. Small screws are supplied by instrument makers for this purpose. They may be used in conjunction with a plate or may be made to act through the medium of gold bands or narrow gold frames fitted to the necks of the teeth. The screw is tightened from day to day by the dentist or the patient's attendant. A jack-screw across the palate, neatly and securely arranged, does not give rise to so much discomfort as a larger apparatus, the use of which it renders unnecessary.

It has already been stated that in all cases in which a relapse after regulation is likely to occur—and this includes almost every case in which the teeth are not kept in position by the bite—a retaining plate must be worn for a period to prevent the teeth from falling back into their faulty position. The slighter the movement of teeth caused in regulation, the more slowly they have been moved, and the more youthful the patient, the shorter will be the length of time during which a retaining plate need be worn ; but as these circumstances vary infinitely it is not possible to lay down any fixed rule The time, as stated on a previous page, varies between a few months and one or two years. On discarding a retaining plate, the patient must be seen after a short interval, and if tendency to relapse appear, use of the plate must be resumed. Casts taken when the retaining plate is given up are useful to compare with the mouth for readier detection of relapse. The objections which apply to ordinary regulating plates apply also to retaining plates, but as the latter can be more frequently removed the danger from uncleanliness is not so great. In some cases retaining plates may be dispensed with during the day and worn only at night or conversely ; and in many cases they may be left out during meals, so

that the teeth may receive the salutary friction of mastication, besides undergoing a thorough brushing and

Fig. 110.

cleansing before re-insertion of the plate. The more free the surfaces of the teeth are left, the less the danger

Fig. 111.

of injury, and, therefore, plates forming closed cells for the teeth are to be avoided in favour of thin, carefully-

adjusted, polished metal straps covering a small surface only. Good forms of retaining plates are shown in figs. 110, 111 and 112, from Quinby. In some cases a metal (wire) splint secured by collars to teeth and moulded to

FIG. 112.

the surfaces of those to be retained answers well. The fixing collars or bands are best cemented to the teeth to which they are attached, and they must be examined at intervals to guard against lodgment of *débris* through

FIG. 113.

failure of the cement around the teeth. Retaining splints of this type are certainly not so likely as plates to cause injury. The cut (fig. 113) from Talbot depicts a splint of this kind.

It is not within the scope of this manual to enter further upon a description of all the numerous expedients which have been adopted in the devising of instruments for regulating the teeth. This is a topic which really pertains not to the study of dental surgery, but of dental mechanics—a separate subject to which the student is bound to devote sufficient attention before entering upon the practice of surgery. Enough—it is

FIG. 114.

hoped—has been said to make clear the principles upon which construction of apparatus is uniformly based, and indeed these principles alone being understood, there are few cases in which the designing of an instrument to fulfil the necessary objects, can present serious difficulty to any operator, having an adequate knowledge of dental mechanics and possessing a moderate amount of ingenuity.

The Röntgen rays as a diagnostic aid in treatment have been more than once alluded to in previous pages.

To illustrate their use two cases may be briefly cited :—The first was a girl, aged twelve, whose upper jaw is shown in fig. 71. It was a case of anterior protrusion, in which it was desired to begin the usual treatment. The right permanent canine had not appeared, and could not be felt or perceived as is usual in a prominence of the alveolar wall. The tooth was absent in other adult members of the family. The X rays demonstrated the absence of the tooth as shown in the skiagram, fig. 114. The mark (o) denotes the position in

Fig. 115.

which the permanent canine ought to have been found ; the cross indicates the temporary canine which had not yet been extracted.

In the next case (a boy, aged nine), the lateral incisors were very slow in developing. They could not be made out by external examination, and they were besides missing in the patient's mother. The Röntgen rays revealed the presence of the missing teeth as seen in fig. 115. Their edges, concealed within the bone, are indicated by the marks +.

Before leaving the subject of treatment of irregularities, a brief account must be given of a procedure for regulating teeth by means of a surgical operation introduced and

elaborated by Dr. Cunningham, of Cambridge. This procedure was suggested by observation of the easy repair which usually takes place after fracture of the jaws, even when accompanied by dislocation of teeth. The operation consists of the artificial production of a fracture which renders it possible to move the tooth into a new position without severing its attachment to the periosteum and socket. Dr. Cunningham commenced by treating single teeth, but, finding the operation successful, extended it to cases where many teeth needed moving.

The operation is carried out by dividing the gum and alveolus on either side of each tooth which is to be moved and then with suitable instruments luxating the misplaced teeth together with their alveoli into their normal position, and in fixing the teeth in their new positions till such time as the divided bone shall have re-united.

Division of the bone is performed with a specially designed hand fret saw. Special instruments have been devised for the luxation of the teeth, either outwards or inwards, also various forms of forceps useful in the operation.

Before performing the operation, it is well to imitate it on a plaster cast, by cutting off and re-fixing the teeth in the proposed new positions. A metal splint is then made to the altered cast. When the operation is finished this splint is fixed in place with phosphate cement. If the luxated teeth do not readily retain their position, but tend to spring back, they must be held by ligature or other means, until the splint is secured in position. Absolute fixity of the teeth is of prime importance. Teeth may thus be moved from within, outward, or *vice versa*, or laterally, as well as more or less rotated, and in the majority of cases, without death of the pulp ensuing.

Occasionally it may be necessary to excise a complete slice of bone with the saw, or to remove by means of drills and burrs part of the bone, in order to facilitate the movement of the tooth and its socket in the desired direction.

The operation should be, so far as possible, carried out antiseptically. All the teeth should be thoroughly scaled, cleansed and filled, and an antiseptic wash freely used previous to the operation. After the operation the same wash should be used, and all the bleeding or cut surfaces should be painted with Richardson's Styptic Colloid. A period of from three to four weeks is ample time for retention by ligature or splints.

Dr. Cunningham has records now of over one hundred operations, without the occurrence of any serious untoward result. In a very small proportion of cases, a few pulps and still fewer teeth have been lost.

The chief objections to this procedure are the same as those given on an earlier page against the operation for removal of developing bicuspids. The operation is relatively a severe one, and the necessary employment of prolonged anæsthesia introduces an element of danger to life. This latter point is one which under no circumstances can be properly concealed from the custodians of children, and with a knowledge of it few will give their consent to the operation.*

* In consequence of an error, undiscovered until the sheet had passed through the press, fig. 114, page 174, has been printed upside down.

CARIES.

Caries, or decay of the teeth, is by far the most important of dental diseases. It is a malady universally spread—few individuals passing through life without an attack in one or more teeth—and with its sequelæ it furnishes the great majority of cases with which the dentist is in practice called upon to deal.

Owing to the relatively simple structure of the dental tissues, and to the external exposed position of the organs which allows the processes of disease to be closely watched, the phenomena of caries, in comparison with those displayed in the pathology of more complex and hidden parts, form an easy problem to investigate and to understand. There is nothing in the subject, whether as regards demonstrated facts or disputed points, which cannot be grasped by a student of average capacity, who comes provided with the necessary fundamental knowledge of physiology, chemistry and bacteriology. Without such knowledge he can neither understand dental caries, nor the other different problems of surgical pathology which he is obliged to master.

The issues involved in controvertible questions concerning caries are few, narrow and easily intelligible; and the student, having the facts and theories fairly laid

before him, should have no difficulty in forming a correct judgment upon them. It is the purpose in these pages to give first, that explanation of the nature of caries which is supported by the greatest mass of demonstrated and demonstrable fact, and which, in its essential parts, is adopted and expounded by the great majority of investigators having valid claim to authority; secondly, to set forth from the writings of these investigators, such matters as may serve not only to make the preliminary explanation fuller and clearer, but also to expose the fallacies of other views which have been propounded; lastly, it is proposed to discuss at greater length objections to the exposition, and to examine how far they affect its character as a true and sufficient explanation of the nature of dental caries; and this examination will include the discussion of additional facts which, it is hoped, may render the whole exposition more clear and exhaustive. Such a method of treating the subject must, whilst precluding brevity, necessitate a considerable amount of repetition; but this, probably, will prove neither distasteful nor disadvantageous to the average student. In any case, it must be borne in mind that caries is the malady around which, more than any other, the practice of dental surgery centres; and, in this regard, the causation of the disease and the phenomena of its progress, must always be of supreme importance.*

Definition and General Description.—Caries is a process of disintegration, commencing invariably at the surface of the tooth, proceeding inwards, and due entirely to external agents. Dentine being a sensitive

* Research into the nature of caries is by no means difficult. Every advanced student should be able to examine and verify for himself the facts—physiological, clinical and experimental—upon which the account of caries in this book is founded.

tissue, its exposure during the progress of caries sometimes, although by no means always, is attended by pain; but except in the manifestation of this one subjective symptom, both dentine and enamel are passive under the process of disintegration, and manifest neither pathological action nor vital reaction of any kind. By pathological action is here meant morbid changes in the tissues excited or produced through the influence of the vascular and nervous systems; and by vital reaction any change in the tissues not solely excited and produced by external agents.

Caries traceable to the same series of causes, both remote and direct, and accompanied by tissue changes identical in every essential particular, may occur in natural teeth or in blocks of ivory refixed in the mouth by artificial means. By subjecting extracted teeth to the influence of agents, with imitation of the conditions existing in the mouth as to temperature, moisture and presence of micro-organisms, caries can be artificially produced, indistinguishable in essential characteristics from that occurring in living teeth.

The onset of caries is favoured, and its progress is hastened by certain innate structural defects of common occurrence in enamel and dentine, and by some diseases of the buccal mucous membrane and some derangements of the general health. Crowding and irregularity of the teeth form also a predisposing cause of caries.

Except in some rare cases, to be in due course described, caries, unless checked by art, having once attacked a tooth, advances towards the interior, forming a cavity, which increases in size until the crown, and even the greater part of the root also, are destroyed. It is commonly attended with pain, which often commences in a mild form as soon as the dentine is slightly penetrated, and becomes most severe when the central

chamber is closely approached or laid open, and the pulp, being exposed to the action of external irritants and to injury, becomes the seat of inflammation.

Etiology and Pathology.—To understand the nature of caries, it is necessary first to bear in mind that enamel and dentine are soluble in acids which often exist in the mouth, and that inherent structural defects in enamel and dentine, presently to be described, both furnish, in a large number of instances, lodgment for acid-forming substances, and render the ill-formed portions of the teeth easily acted upon and destroyed.

The active agents in caries are acids and micro-organisms. The acids, principally lactic, malic, butyric and acetic, are mainly the products of putrefaction and fermentation, set up in fragments of organic matter, food, mucous and epithelial scales, which are commonly present in the mouth.

These acids are often assisted by others derived from different sources. Some may be secreted by the mucous membrane. The normal secretion of the membrane is small in quantity and slightly acid. In health, the acid is at once neutralised by the alkaline saliva, with which it mingles; but when the membrane is congested or inflamed, the mucus increases in quantity, and becomes more strongly acid in character. This was proved many years ago by the classical experiments of Sir J. Tomes. Again, acid is eructated in many gastric disorders. Saliva has an acid instead of an alkaline reaction in several diseases; in others, an abnormal amount of acid mucus is secreted by the gums. The solubility of dentine and enamel in acids not more powerful than would be derived from the several sources named can be demonstrated by experiment.

The organisms active in caries consist of various species of bacteria and leptothrix buccalis. These

organisms—except leptothrix, which is peculiar to the mouth—are such as are more or less frequently present in fermentation and putrefaction wherever occurring. Fermentation and putrefaction are produced in the mouth by the same causes which give origin to them elsewhere—namely, by the proliferation of micro-organisms. During these processes, as they take place in decomposing substances lodged about the teeth, acid is formed, capable of decalcifying dental tissues; and as this is the main source of acid, and as micro-organisms are essential to the processes of fermentation and putrefaction, these germs must be looked upon as prime factors in causation of caries. The organic fragments and decomposing tissues occupying a carious cavity, exhibit, either constantly or at intervals, a markedly acid reaction, and on analysis yield an appreciable per-centage of acid.*

The factors in the direct causation of caries are, first, a weak spot in the enamel, or the retention of acid-forming agents in contact with its surface; secondly, acids and organisms in sufficient quantity to effect disintegration of the tissues. That acids alone do not produce all the phenomena of caries is proved, not only by the presence invariably of micro-organisms, but also by the fact that in the progress of the disease destruction of dentine is more rapid than of enamel, whereas acid acting alone would completely destroy the enamel, but only partially destroy dentine. It is, on the other hand,

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* Besides the organisms which, directly or indirectly, are engaged in destruction of the tissues in dental caries, there are usually to be discovered in the mouth many other varieties of the germs always floating in the atmosphere. These germs mingle with the secretions and find lodgment about the teeth and in carious cavities. A cavity of decay when undisturbed doubtless forms frequently a favourable nidus for some species. Of these organisms of the mouth some are innocuous, some septic, and some pathogenic, whilst others are capable of conveying the specific toxins of local or systemic disease. The bacteriology of the mouth is more fully discussed in Appendix A.

inconceivable that micro-organisms could gain access to the dentine without the assistance of an acid capable of perforating enamel. In experimental decalcification and disintegration of extracted teeth by acids alone, the tissue-changes do not present complete resemblance to caries—the enamel being slowly destroyed first, and the dentine rendered gradually soft and elastic by removal of its lime salts.

The dependence of the processes of fermentation and putrefaction upon the action of micro-organisms, has been demonstrated only within comparatively recent years. And since putrefaction and fermentation must certainly occur in the matters lodging upon the teeth and within a carious cavity, and since decomposition of that kind cannot go on without the assistance of micro-organisms, the presence of these germs in caries might have been safely predicted, so soon as Pasteur's discoveries were established. Organisms are, in fact, not only present invariably as soon as carious action is started, but in every case, without any exception, they are found occupying the dentinal tubes during the progress of the disease. Of the organisms found in a cavity and within the tubes cocci are the most frequent; they occur in the form of groups (staphylococcus), pairs (diplococcus) and chains (streptococcus). Bacteria proper — rods of varying length—are less abundant. Leptothrix is found in all cases, especially on the surface of decay; but sometimes it appears almost alone in the cavity and dentinal tubes. Bacteria in the comma form and as spirilla and spirochæta also occur, but not in relatively great numbers.* Torula—one of the true organisms of

* Recent researches point to the conclusion that in some instances various forms, apparently distinct, may merely represent phases in the life-history of a single organism.

fermentation—is frequent, appearing mostly on the surface among particles of food, but also occasionally in the tubes. The organisms primarily active in caries are those that give rise to acetous decomposition and fermentation. The part played by other varieties consists mainly in helping to break down the organic basis of dentine in which and in the fibrils they proliferate and probably find pabulum.

Caries often commences on a surface of a tooth perfectly free from inherent structural defect. This occurs especially on lateral aspects, or on interstitial surfaces bordering nooks and crannies formed by irregularity and crowding; for it is in these situations, where the shelter allows particles to remain undisturbed for lengthy periods, that organisms and acids are constantly generated during the decomposition of *débris* of food and irritation of the mucous membrane.

Caries frequently has its starting point at some part of the enamel and dentine, the seat of innate structural defect. Imperfections in structure, from which few sets of teeth are altogether free, may be owing to defect either in the quantity or in the quality of the tissues. Defects in quantity consist of pits and fissures in the enamel and dentine. These vary in extent between minute cracks perceptible only under the microscope, and cavities—as displayed, for example, in honeycombed teeth—plainly visible to the naked eye. They may penetrate the enamel alone, or may extend to a greater or less depth into the dentine also. The most common situation for cracks and fissures is in the depths of natural depressions in the contour of the tooth, as for example, between the cusps of bicuspids and molars, but they are also not unfrequently found on the lingual surface of upper incisor, in the centre of the buccal surface of lower molars and in other positions. Minute

cracks in enamel visible under a low magnifying power, are often to be found here and there in teeth otherwise of perfect formation. Fissures which involve the dentine as well as the enamel are the most favourable to the attacks of caries.

Defects in the quality of the tissues may involve the whole body of the tooth, or may be confined to certain spots in the enamel and dentine. That the dental tissues vary infinitely in strength in different individuals is demonstrated daily in dental practice. In well-made teeth, the sound enamel—as hard as quartz—tries the steel of the best tempered drill or chisel. On the other hand, badly formed teeth are commonly met with, of which the enamel, untouched by decay, is throughout of almost chalk-like softness. If the enamel and dentine of delicate teeth, unaffected by caries, be examined microscopically, it will be found that both one and the other present well-marked evidences of imperfect formation. The enamel instead of appearing a densely hard, almost homogeneous mass, is comparatively soft, owing to imperfect calcification, and porous, in consequence of incomplete coalescence of its formative elements. It retains a marked fibrous character. The fibres are imperfectly blended, their transverse striæ are clearly evident, and they are often penetrated at their centres by tubes or small cavities. At parts, the fibrous character may be altogether lost, the tissue consisting of an imperfectly united granular mass.

The dentine exhibits at parts throughout its structure, and especially immediately beneath the enamel, patches of soft, ill-calcified defective tissue, similar in character to the globular layer, which, in well-formed teeth, exists only at the point of juncture with the cement. In the spaces within this defective tissue—sometimes called interglobular spaces—the tubes end, or they may even

run on, and terminate in dilated extremities within the substance of the enamel.

Innate structural defects of typical character are well shown in the photo-micrographs, figs. 116, 117, 118, and 119. These sections are all taken from teeth unaffected by caries, and presenting neither flaw nor blemish discoverable by the naked eye. In fig. 116, the enamel, tolerably sound on the surface, shows at intervals granular patches extending towards the dentine. The dentine displays large areas of globular (imperfectly calcified) tissue at short intervals. Fig. 117, exhibits a minute fissure at the surface, surrounded by a considerable area of granular tissue, in which the fibrous arrangement of normal enamel is quite absent. This surface, under the microscope, also presented a flaky appearance, such as on a larger scale is seen on the outer surface of an oyster shell. Fig. 118, shows a surface-fissure in enamel, also widely bordered by ill-made tissue—porous and granular. Such a fissure, although minute and invisible without the microscope, is large enough to allow penetration of fluid with minute organic particles, which would form a nucleus for decomposition. In fig. 119, is beautifully displayed successive strata of globular dentine, from the same tooth from which the section of enamel shown in fig. 118 was taken. In this tooth, a slight thickness of tolerably well-made dentine underlay the enamel, but the globular strata extended widely in all directions at the depth and at the intervals shown in the photograph.

It does not always happen, by any means, that all the structural defects in the quantity and quality of the dental tissues, which have been just mentioned, commonly exist together in one tooth. Their degree and character vary infinitely. It would probably be very difficult to find a set of teeth of otherwise good organisation, in the members of which one or two pits

FIG. 116.

Section of enamel and dentine, showing inherent structural defects in both tissues. The dark shaded patches in enamel are granular portions; those in the dentine are globular structure—ill-calcified tissue containing lacunæ filled with organic matter. From a tooth free from caries and presenting no external mark of defect. Photo-micrograph by Mr. Charters White.

FIG 117.

Section of granular enamel from the surface of a tooth free from caries, and displaying to the naked eye no apparent defect. × 150.

FIG. 118.

Fissure and granular enamel at the surface of a tooth free from caries, and without any blemish visible to the naked eye. × 150.

FIG. 119.

Section of inherently defective dentine displaying at a slight depth beneath the enamel successive strata of globular tissue. From a tooth free from caries, and with no superficial defect visible to the naked eye. × 150.

or fissures, or small patches of defective enamel were not discoverable; whilst in teeth, of which the structure generally is inferior, there are often to be discovered isolated portions of still feebler formation. These facts must be borne in mind in considering both proximate and remote causes of caries.

Ill-made tissues—enamel and dentine—imperfectly calcified throughout or in part, constitute one of the main predisposing causes of caries. A second cause is crowding and irregularity of the teeth, due to smallness and malformation of the maxillæ. Whilst it is the exception to find an individual of a civilised race with dental tissues in every tooth perfect in structure, it is equally uncommon to find one with jaws perfectly formed and of full size. In a well-developed jaw every tooth is subjected to the constant beneficial friction of the tongue, and of food during mastication; whilst all the dental surfaces are in health constantly washed by alkaline saliva. These conditions render impossible the prolonged lodgment of decomposing, acid-forming products about the teeth, and so one potent factor in the causation of caries is absent. But it is the exception to meet with a case in which at least some crowding of teeth does not exist—most often there is a want of space, the teeth being closely impacted, and one or other of the set more or less overlapping its neighbours. Between such slight cases all degrees of crowding and irregularity are to be observed up to the extreme instances, described in a previous chapter, where the teeth at places are found leaning at all angles, wedged together in what looks like one confused mass. It is easy to understand how such conditions of crowding and irregularity make certain the accumulation of decomposing foreign particles in the unnaturally narrow interstices between the teeth, and in the nooks and crannies formed by irregularity.

It is especially necessary to note the fact, that the extent and character of irregularity and crowding of the teeth vary infinitely in different individuals.

To structural defects inherent in the tissues and irregularity and crowding of the teeth, a third predisposing cause of caries must be added. This is made up of all conditions of health accompanied by vitiation of the buccal secretions, and all habits of dietary and local uncleanliness, which tend to the formation or deposit of acid, and the accumulation of products of decomposition within the mouth. This is, perhaps, the most important of the predisposing causes of caries. It is quite evident that however defective structurally enamel and dentine may be, they cannot become the seat of carious action without the formation and deposition of acid upon the surface of the teeth. Professor Wedl classed caries under "Anomalies of the Secretions," holding that it was not really a disease of the dental tissues, but rather disintegration of the tissues, due to the physical effects of the vitiated secretions. It is evident that with a free flow of healthy saliva, and a due secretion of normal mucus, there would be much less caries, but the opportunity which is afforded by structural imperfection of the tissues and irregularities of the teeth for the prolonged lodgment of *débris*, and its fermentation and putrefaction in contact with, or even within the substance of, the enamel, must not be ignored.

Dr. Leon Williams has proved that structural defects in enamel and dentine, of precisely the same character as those occurring in human teeth, are found in some lower animals, including apes, living in a state of nature. In these animals caries does not occur, because the other essential factor, acetous decomposition of foreign particles lodged upon the teeth, is never established.

The association of inherent flaws in dental surfaces with the causation of caries, is too frequent and obvious to escape the notice of the least observant practitioner. Perhaps the most familiar example is found in the first permanent molars. These teeth, the most prone to decay, very often exhibit visible structural flaws which are noticed immediately after appearance of the teeth. The flaws often have the form of minute fissures on the masticating surface in the sulci between the cusps; and in many first molars fissures are found on the labial aspect, sometimes several converging towards a small pit in the centre of the surface. Every practitioner has followed the history of such cases during the periodical examinations to which well-cared-for children are subjected. First, after lapse of months or years, is observed, in many instances, the signs of incipient caries, mainly slight opacity of enamel on the margins of the flaws. After further lapse of time, a sharp probe finds with little pressure its way through the friable enamel into the dentine, in which, if the mischief be allowed to progress, a cavity is soon formed. In neglected molars, in which the minute defects just described have existed, it is not uncommon to find a cavity in the masticating surface, sapping vertically, which communicates with another, proceeding horizontally inwards from the labial aspect, whilst the rest of the tooth, being smooth and free from inherent flaw, has not been attacked. Food particles of certain kinds lodging within defective spots ferment and form acid. This, given time enough, is sufficient to establish caries, and the disease would not have arisen had not structural defects in the teeth pre-existed. The phenomena attending the origination of caries in inherent flaws are often thus gross and palpable; and there can be no doubt the same results are produced where defects

exist which are not easily visible or are even invisible to the naked eye, and yet allow entry of minute particles of fermentable matter to within the substance of the tissue.

There is hardly a single derangement of health which is not attended by vitiation of the secretions of the mouth. The physician finds, as a rule, no surer indicator of a lowered standard of health than a foul tongue. From the occasional coated tongue and clammy mouth accompanying a transient attack of dyspepsia—from which probably even every robust individual suffers now and again—every degree of derangement of the secretions of the mouth is met with in disease, up to the severe condition associated with the zymotic fevers, such as small-pox or typhoid. During these diseases the secretion of saliva is scanty, often almost suppressed, and the teeth remain, perhaps for weeks, coated with sordes—accumulations of epithelial scales, viscid mucus and other foul secretions, crowded with bacteria and overgrown with leptothrix. The condition of ill-health accompanying pregnancy in some women furnishes another instance in point. In most of these cases the symptoms are due to or associated with disorder of the digestive organs. The appetite is morbid and capricious; vomiting and eructation of food frequent; the tongue is foul, and the gums very frequently in a condition of chronic congestion or sub-acute inflammation, attended with erosion of epithelium and secretion of muco-pus or tenacious mucus around the necks of the teeth. Then, in gouty attacks, the saliva has often an acid instead of alkaline reaction. In tuberculous subjects of the "scrofulous" type, there is commonly a characteristic condition, marked by chronic congestion and swelling of the gums, with secretion of viscid mucus. Some phases of syphilis and of phthisis, diabetes, chlorosis, and chronic alcoholism, are marked by congestion and inflammation

of the gums, by stomatitis in some form, or by distinct and easily recognisable morbid changes in the secretions of the mouth.* It is needless to multiply instances, or to examine further or more minutely these affections. The main point to be observed is that like the other predisposing causes of caries, this last varies infinitely in different individuals; but, unlike the other causes, which are constant and persistent, vitiation of the secretions is marked by the utmost variability and inconstancy; for it attends throughout life, in corresponding proportion, the smallest, not less certainly than the greatest, departure from the standard of perfect health. There can be little doubt that some morbid conditions of the buccal secretions favour more than others the process of acid fermentation in *débris* lodging upon the teeth, but this subject has not yet been fully investigated.

If all these facts upon the subject of predisposing causes of caries be kept in view, there need be no difficulty in understanding how the origination of this affection is often coincident with the outbreak, and its advance synchronous with the progress of constitutional disease; nor in understanding how caries, when previously present in an incipient stage or slowly progressing, may, under these circumstances, be accelerated, and run a rapid course. It is instances of this kind which have led to the assumption that the destructive process may be induced or hastened by morbid influences acting from within the teeth—an assumption about which more will be said presently.

* By directly acting upon the teeth and by augmenting the general acidity of the secretions, acid medicines—particularly tincture of iron and the mineral acids—may aid in causation of caries. Improper dietary may act in two ways: by deranging digestion it may give rise to foulness of the secretions; by introducing certain articles it may directly promote fermentation and putrefaction within the mouth. Sugar, the abuse of which, in form of sweetmeats, is so common with badly-managed children, no doubt acts in both these ways.

The facts that enamel and dentine are soluble in acids, the existence of which in the mouth commonly arises from various sources, and that inherent structural defects in enamel and dentine not only furnish places favourable for the lodgment of acid-forming substances, but, at the same time, render some portions of the teeth more readily acted upon than others, suffice, in many cases, both to explain the origin of caries and to show why the disease commences at certain isolated spots, and does not affect uniformly and at once the entire surface of the crown of a tooth. The incidence of caries, its localisation in certain teeth is, as just explained, also often governed by conditions of crowding and irregularity. Consideration of these facts, with the others bearing upon the etiology of caries, enables us not only to understand its common association with various diseases and cachexiæ, but also makes clear why caries, to a greater or less extent, shows itself, sooner or later, in every individual whose dental development is not perfect, and whose general health is not invariably at the highest level. Given, first, innate structural imperfection of the tissues, varying infinitely in different individuals; secondly, crowding and irregularity of the teeth, equally varying in degree; and, thirdly, vitiation of the buccal secretions, not only varying in amount, but extremely irregular in appearance and in duration through periods in the life of different individuals, and we account fully for the etiology of caries without needing to invent any questionable hypothesis. The mutual relation of these causes is, of course, often too subtle and too intricate to be traced, even if we had the patient under constant observation; but these causes are demonstrable; they suffice to account completely for the effects ascribed to them, and, as will be presently seen, these effects cannot be accounted for on any other

theory, unless based upon suppositions irreconcilable with the anatomy of the dental tissues, and incompatible with clinical and experimental fact.

The stages in the progress of caries are as follows:—The enamel is first perforated by acid, and the resulting cleft, cavity, or porous or roughened surface, forms a depôt for the lodgment of decomposing particles. When dentine is reached the organisms proliferate in the fibrils along the tubes, and, producing acid, dissolve the lime salts from the matrix. As the organic basis of the tissue becomes decalcified, this also furnishes pabulum to the organisms, and the destruction of the dentine is thus gradually completed, whilst the enamel, partly dissolved and undermined, either remains as a wasting shell or breaks away for lack of support.

Some observers are of opinion that following upon the decalcification of the dentine, the acid-producing, or other bacteria, exert a peptonising action upon the residuary fibrous matrix, and that this is liquified and removed by this means. Certainly, large spaces may be found in carious dentine filled with micro-organisms, but they show no appearance which may not be due to decalcification direct, and the amount of organic matter in dentine is comparatively so small that it seems almost unnecessary to attribute more than a very small share in the breaking down of the dentine to any but an acid action.

The macroscopical appearances exhibited by enamel and dentine in caries, consisting mainly of discolouration, softening and disintegration of the tissues, bear a general resemblance in every case. They differ only in consequence of the mode of onset, the situation and rapidity of the disease. The discolouration in the incipient stage on an unbroken surface of enamel usually amounts to no more than slight opacity of the tissue; it has lost its

translucency and looks white—a condition which also, as a rule, prevails throughout the later stages on the borders of the cavity of decay. When the disease begins in a fissure, and when a cavity is formed, the discolouration is more marked—the softened dentine assuming a brown tint, or becoming stained to a blackish hue. This discolouration is probably, in many instances, due to the presence of pigment-forming bacteria.* It has been proved that bacteria produce pigment, and moreover that several varieties produce their own particular pigment, one kind black, another yellow, a third green. Cavities in which the disease is progressing rapidly show, as a rule, least discolouration.

This is often exemplified in decay of approximal surfaces; one tooth will, in these situations, frequently be found extensively carious, without any very notable discolouration, whilst the other shows only a discoloured —perhaps black—patch, due to merely superficial pigmentation of the enamel.

The softening and disintegration perceptible in the successive stages of caries vary considerably. When a surface of enamel is sufficiently affected to display gross, recognisable, physical changes, it appears eroded, rough, and full of small holes, is readily scraped away by a steel instrument, and is evidently softened. The contrast between carious and sound enamel is most conspicuous in teeth of good formation. The carious enamel is easily cut through and broken down by the chisel or drill. It is chalky and friable, whereas the unaffected margins of the cavity offer great resistance to cutting instruments. When the mischief has

* It is not necessary to suppose the presence of special pigment-forming organisms where colouration appears such as is present in caries, since it has been proved that pigmentation is a very common occurrence during proliferation of organisms of every kind.

commenced in a fissure, little softening may be apparent for a time at the surface, but at length the undermined enamel, breaking down or being cut away, discloses a cavity in the dentine filled with disorganised tissue. Such a cavity is formed in most cases in the latter stages of the disease. The greater enlargement of a cavity in the deeper parts is due, first, to the fact that the dentinal fibrils and the organic basis of dentine help to furnish pabulum for micro-organisms; secondly, micro-organisms produce acid, and this acid is obviously most abundant and active in the depths of a cavity where it is least disturbed and least diluted by access of saliva. Moreover, each tubule forms a channel through which the disease is conveyed onwards. To this circumstance is due the fact that cavities within the dentine are very commonly in shape like a cone with the apex deepest — this shape corresponding to the radiating arrangement of the canals. Such a cavity very often communicates with the surface by only a small opening, or through porosities caused by acid in the undermined enamel.

Variations in the physical character of the disease, due to the different power of resistance of the tissues in different cases and to other accidental causes, have given origin to such distinctive terms as "spreading," "penetrating," "soft" and "hard" caries. Thus, when caries invades a mass of interglobular substance, it is easy to understand how the disease advances with greater rapidity at that part than at the superficies. On the other hand, when the surface of a tooth is composed of defective enamel, as in hypoplastic teeth, whilst the underlying tissue is of good structure, caries will spread faster than it penetrates. These variations were looked upon by older observers as distinct varieties of the disease, due to pathological factors.

Tobacco smoke, preparations of iron taken as medicine, and such-like ingesta, which the patient may be in the habit of using, are apt to stain carious tissues and alter their appearance.

In some few cases carious cavities become completely filled and covered with tartar, owing to the patient having for a prolonged period avoided mastication upon the affected teeth through fear of pain.

A cavity on the grinding surface of a molar, of which the undermined margins of enamel become soon broken down, into which food is forced during each act of mastication, and which is, perhaps, as frequently cleared by a tooth-pick, will, of course, present appearances different from those displayed by a cavity which, from its position, is left undisturbed for a prolonged period. Cavities of the latter class, oftenest found in closely impacted mesial or distal surfaces, will frequently be found covered with a shell of enamel, apparently unbroken, although really porous and friable, and penetrated by minute microscopical canals, allowing passage of micro-organisms to the dentine within. When the investing thin shell of carious enamel is cut through, or finally gives way as decay advances to the grinding surface of the tooth, the interior is frequently found to be filled with the organic frame of the dentine retaining its form, but in a more or less disorganised, softened and moisture-soaked condition, the mass varying in consistency between soft deal and sodden cardboard. The softened tissue is easily cut, and it comes away in large, coherent flakes. This condition, which exemplifies in the gross the stage of preliminary softening prior to disintegration, so often distinguished by investigators, is probably of most frequent occurrence in teeth with inherently soft, ill-calcified dentine, and in which decay has run a rapid course.

The illustration, fig. 120, will be further explanatory of the particular phase of caries, which may be called the incipient and first stage, described in the last paragraph. It shows a section of a bicuspid tooth under low magnifying power. The tooth, before extraction, was completely covered by a mass of organisms, matted into a felt-like agglomeration. It

FIG. 120.

Copied from a photo-micrograph of a preparation by Dr. Leon Williams.

can be seen that the acids formed by the organisms have produced changes at parts throughout the entire thickness of the enamel and dentine, and have entirely dissolved a certain amount of deeply-placed enamel. The area of destroyed enamel is indicated in the engraving by the black patch between the enamel and

dentine on the right side. No actual breaking down of enamel externally had taken place in this specimen. The shaded areas in the engraving show deeper portions of tissue, which have been acted upon by the acids of decay. The minute effects of these acids upon enamel are shown clearly in fig. 121, a similar preparation, under a much higher power.

Microscopical examination of carious teeth* and of carious dentine, without any exception, discovers the presence of micro-organisms, not only in the cavity but also invariably within the tubes.

The *débris*, occupying a carious cavity made up of extraneous particles, fragments of food, etc., which have entered from the mouth, together with broken-down remains of disintegrated dental tissue, can be easily examined microscopically. Stained with fuchsine or methyl violet the organisms are easily distinguishable. The varieties of organisms met with have already been named, but among them in this part of a carious cavity more torulæ (the special organisms of fermentation) are found than deeper and within the tubes. Baccilli undergoing spore formation, which do not occur at all within the tubes, are here also usually present.

The general appearance of carious enamel under minute examination, does not widely differ from that produced by experimental decalcification out of the mouth, except that the affected tissue is frequently more or less pigmented, and that micro-organisms pervade all fissures and openings large enough to allow of their entry.

The appearances, under a low power, vary very much in accordance with the structural character of the

* For account of method of preparing and examining the microscopical sections of carious teeth, figured in this work, see Appendix B. Many hundreds of sections were cut, stained and examined during preparation of the third edition.

attacked surface and other circumstances. The tissue may have been of perfect quality, or the seat of a pit or fissure, or may present any degree of the inherent imperfections which have been just described and illustrated. The acid travels first along the line of least resistance. This line, as Dr. Leon Williams has clearly shown, lies in well-formed enamel through the

FIG. 121.

Section of carious enamel, under high power, showing mass of adherent organisms and formation of openings into the substance of the tissue by the action of acid.

Copied from a photo-micrograph of a preparation by Dr. Leon Williams.

cement substance uniting the prisms. Sir J. Tomes believed that, as a rule, the centres of the prisms are first affected, and since the central portions of the prisms are

occasionally ill-formed—sometimes they are tubular—in inherently defective tissue, there need be no doubt that Sir J. Tomes' observation was, in a certain number of cases, correct. Where a granular condition exists the fibrous character is, of course, absent altogether. As soon as porosities or perforations of sufficient size for the lodgment of foreign particles are formed by the action of acid, micro-organisms can be detected by scraping the surface: and where a pit or fissure (inherent flaw) exists, foreign particles, with proliferating organisms, may be present below the surface from the first.

In the third edition of this work the statement was made that "to cut a section of carious enamel sufficiently thin for examination under high microscopical power is impossible; it is too friable and breaks down before the necessary degree of tenuity is reached." This difficult feat has since been accomplished by Dr. Leon Williams.

Fig. 121, from a preparation by Dr. Leon Williams, illustrates his description of the typical microscopic appearances in an early stage of caries of enamel. The section was prepared by grinding it in such a manner that the affected surface remained undisturbed after removal of an adherent mass of micro-organisms. Looking directly down upon the surface it is seen that the enamel is everywhere perforated by funnel-shaped openings leading to canals. These canals often penetrate the entire thickness of the enamel. Dr. Leon Williams states that these appearances and effects closely resemble the experimental decalcification of enamel by lactic acid. The acid acts more quickly upon the cement substance uniting the rods than upon the rods themselves, and this is exactly what happens in caries. Dr. Williams believes decalcification is often caused by acid secreted by the masses of organisms alone. As

soon as fissures are formed organisms are found proliferating within them. The weakening goes slowly on until the tissue becomes friable. In this weakened condition it may remain for some time if not subject to injury, but at length it begins to break down, forming a cavity, as shown in fig. 122.

FIG. 122.

Commencement of formation of a cavity in caries of enamel. The "felt-like" mass of organisms lines the cavity. The shaded area shows the depth to which the acid of decay has acted

Copied from a photo-micrograph of a preparation by Dr. Leon Williams.

Dr. Williams states that on undisturbed surfaces of enamel, where decay is either commencing or where a cavity has already formed, a mass of organisms can always be demonstrated by careful manipulation, and

the mass is usually so coherent as to assume a "felt-like" consistency.*

At the outer margin of a cavity in the portion of carious dentine on the point of breaking down, but with sufficient coherence to allow of the cutting of a section, the tubes are almost indistinguishable. The whole seems made up of a mass of organisms matted together in zooglea form, and partly supported by a trace of the organic basis of the tissue.†

Fig. 123 shows a typical section through the outer margin of a carious cavity,‡ under low magnifying power. The black shaded portions are masses of organisms, which can be distinguished under the microscope, but owing to the thickness of the layers cannot be differentiated in a photograph. At the blank spaces—probably where the weakest portion of dentine or globular structure had existed—complete destruction of tissue has taken place. The deeper dentine retains its form, the tubes being enlarged and filled with organisms. Still deeper the tubes filled with organisms are less enlarged, whilst, as the verge of unaffected dentine is approached, tubes may be seen exhibiting no perceptible increase in diameter, although their fibrils to some depth have been destroyed by proliferating organisms. In fig. 124 are exhibited the microscopical appearances in advanced caries, but where the dentine is still far from broken down. The magnification (× 650)

* Figs. 120, 121, 122, are somewhat diagrammatic reproductions from photo-micrographs by Dr. Leon Williams, showing the exact appearances.

These photo-micrographs have been published (Dental Cosmos, 1897), but the blocks could not be obtained for this work.

† This description which was first given by Messrs. Pound and Henry Sewill, in the 3rd edition of this book, closely corresponds with Dr. Leon Williams' description of the "felt-like" mass of organisms just cited.

‡ The sections illustrated were all prepared by the Gram method with some modifications By this method the organisms alone are stained, the dentine left normal in colour. For full account of the method see Appendix B.

is here large enough to allow micro-organisms to be clearly visible under the microscope, and many are distinctly individualised in the photograph. In this specimen they are mostly cocci. The dark-shaded patches are masses of organisms lying on different planes, so that to produce photographic distinctness of individual organisms is impossible. In fig. 125 there is shown a section (× 600), in which the tubes are mainly occupied by leptothrix.

In the vast majority of carious teeth cocci form the great bulk of organisms within the tubes, and although leptothrix is invariably present on the surface, it is only in rare cases that it alone occupies the tubes.

In the photograph, fig. 126, are clearly exhibited the appearances of carious dentine at an early stage of decay. The less affected portions of such a section would present, to the naked eye, no evidence of disease. A similar section, under a much higher power (× 650), showing the point of junction of carious and healthy tissue, is shown in fig. 127. Under this power micro-organisms are clearly differentiated, and in the photograph, cocci (which predominate in this section) can be distinguished. In fig. 128 is seen a transverse section of carious dentine (× 650). The organisms are so closely packed that they cannot be differentiated within the tubes; but in sections like this many organisms can always be seen at points where the tubes are breaking down.

The advance of organisms in caries may be likened to the progress of an invading army. On the surface are massed the main hordes, with smaller bodies pushed forward along every avenue (tube); whilst at the farthest limits of the invaded territory, beyond the sphere of decay distinguishable by the naked eye, a few narrow files of bacteria may be discovered by the

FIG. 123.

Section of carious dentine extending inwards from the external margin of cavity of decay. Typical specimen of the appearances under low magnification of carious dentine in the various stages of disintegration. The dark portions above are composed almost entirely of micro-organisms—in this case micrococci. The blank spaces where the dentine is entirely destroyed were probably globular tissue. Enlarged tubes filled with organisms extend below towards healthy underlying tissue. × 86.

FIG 124.

Section of dentine in advanced stage of caries seen under lower power in fig. 123. Tubes enlarged and filled with organisms, mostly micrococci. ×650.

FIG. 125

Section of dentine in advanced stage of caries Tubes much enlarged and filled mainly with leptothrix. ×600.

FIG. 126.

Deeper portion, less carious, of section shown in fig. 123, but under higher magnifying power. Tubes at intervals filled with micro-organisms. This section to the naked eye appears unaffected. × 160.

FIG. 127

Section of carious dentine at point where diseased merges into healthy tissue showing micro-organisms—mostly cocci—proliferating along course of tubes. To the naked eye apparently healthy. × 650.

FIG. 128

Transverse section of carious dentine showing enlarged tubes filled with micro-organisms. ×650.

FIG. 129.

"Pipe Stem" appearance. ×375

microscrope, penetrating like the advanced guard of an invading host. This simile was first suggested by Mr. A. Underwood, who also pointed out the fact that the tubes of dentine around the immediate sphere of decay were always penetrated by organisms, before showing morbid changes recognisable without the microscope.

It was noticed by the earlier dental pathologists, and first by Sir J. Tomes, that certain changes apparently take place prior to actual disintegration, in that portion of dentine through which the disease is advancing, and which is situated immediately contiguous to disorganised tissue. This altered dentine, which is, however, visible only under a low power, has a translucent appearance, and forms either a regular zone, or exists in isolated patches around the walls of the cavity. This phenomenon was once thought to indicate invariably a vital or pathological action, a natural effort to arrest the disease by calcification of the dentinal fibrils. It is found, however, that a precisely similar alteration occurs in caries of dead teeth, and is also produced during the gradual softening of dentine by acid, and to this softening, or some other physical alteration caused by external agents, the effect is due.*

Transverse sections of dentine at the deeper parts of a cavity, where carious action is in the incipient stage, and before micro-organisms have penetrated, mostly exhibit in patches a peculiar appearance, which has been likened to that which would be shown on section of a multitude of tobacco-pipe stems united by an intervening substance. This appearance also was once thought to indicate pathological activity, but it has been proved that it occurs in dead teeth, and can be produced by chemical reagents which render prominently visible the dentinal

* Some recent observations would, if confirmed, tend to modification of this view. These observations are discussed in later pages.

sheaths—the sheaths of Neumann. This appearance was first described by Sir J. Tomes, who characterised it in the manner which is here adopted. The drawing with which he illustrated his description is reproduced in fig. 130. The exact appearances presented under the microscope are shown in the photograph, fig. 129.

Another phenomenon in carious dentine is also discoverable. This is an appearance which, at first sight,

Fig. 130.

looks like "pipe-stem" dentine in vertical section, but on closer examination proves to be distinct. The sections do not take stain as do the "pipe-stems." The tubes seem dilated and filled with highly refractive bodies. These bodies are cylindrical in shape, and they split up into fragments of varying length. It is possible, sometimes, by squeezing a section, to force these bodies from the orifices of the tubes. Transverse sections resemble "pipe-stem" dentine, but the outlines are

smaller in circumference, and the refractive bodies occupy the tubes. This phenomenon can be due to no other cause than the changes in the tubes and fibrils, brought about by gradual invasion of organisms and action of acids and other agents.

Pain in Dentine during Caries and Reaction in the Pulp.—Enamel being devoid of sensibility, pain during caries does not begin before the dentine is affected, and it may be absent in the earlier stages of the disease. In these stages it is due solely to exposure of this sensitive tissue to sudden changes of temperature and pressure of foreign particles and contact with irritating substances. In the later stages of caries, pain arises from the transmission of similar irritation to the pulp, leading to inflammation, when that structure is either insufficiently protected by a layer of dentine, or actually exposed. Finally, if the disease runs on, there is added the pain due to extension of inflammation from the pulp to the dental periosteum.

The amount and character of the pain in all the phases of caries are much diversified in different persons. In some individuals when dentine is reached, there is, almost from the beginning, constant pain of a dull, aching character, which increases from time to time as decay advances into more severe attacks, whilst, in others, teeth are altogether destroyed without any suffering beyond slight occasional aching and uneasiness. It has been believed by some observers that carious dentine, in some cases, displays exalted sensibility —hyperæsthesia. It has also been shown that healthy dentine may present, at parts, areas displaying unusual sensibility, apparently due to presence of an abnormal amount of organic structure. Although the possibility of hyperæsthesia of carious dentine cannot be denied, it is somewhat doubtful whether it really occurs, and its

occurrence certainly cannot be in any case demonstrated. Perfectly healthy dentine is sensitive, and the sensibility is much greater in some teeth than in others, and greater in some parts of a tooth than in others. All observers recognise, for instance, that the tissue is, as a rule, more sensitive immediately beneath the enamel than deeper. In cutting through carious dentine it is very common to pass through a highly sensitive layer into tissue displaying less feeling; but it is questionable whether there is ever to be observed the excitation of greater pain in this than commonly seems inflicted in many instances by excision of healthy dentine, whilst dentine, the seat of incipient caries, shows, as often as not, no apparent increase of sensibility whatever. It is often difficult to distinguish pain referred solely to dentine from that which arises from irritation of a pulp closely approached by decay.

It is impossible to account fully for the difference in the amount of pain arising during the progress of caries through dentine; but there can be no doubt pain is often due to irritation by vitiated secretions. The application of some substance—such as sugar—to carious surfaces notoriously excites pain. In some disorders of health, notably in pregnancy, for instance, where superficial caries is so often attended by considerable pain, this may be presumably due to vitiated buccal secretions, such as in many of these instances are present.

Mr. Arthur Underwood has clearly shown that where extreme sensibility of dentine exists, it may, in rare cases, be traced to the existence within the tissue of what he styles "aberrant nervous filaments"—anomalous filaments—radiating from the surface of the pulp even as far as the deep surface of the enamel. On the other hand, he has pointed out that, in some cases, the pulp may be insufficiently innervated, so that not

only the dentine, but the pulp itself displays little sensibility.

Leaving out exceptional cases, it may, however, be broadly stated that in the vast majority of instances there comes on from time to time, after dentine is affected by caries, slight attacks of transient aching, particularly after entry into the cavity of irritating substances, such as sugar and salt; and a smart pang, slowly subsiding, is often inflicted when a hard fragment of food is forced in during mastication. The pain in this phase of caries is never of a throbbing character.

The etiology, symptoms and pathology of irritation, and inflammation of the pulp and of the dental periosteum associated with caries, are discussed in a later chapter. It may be repeated that the most severe pain which arises during the progress of caries is due to inflammation of the pulp. It is by the extension of this inflammation that the dental periosteum becomes involved.

It must, however, be here noted that reaction in the pulp and vascular connections of the teeth are not necessary accompaniments of caries of enamel and dentine, as they would be if this malady were of inflammatory origin. When such reaction occurs it arises in the later stages, as the result—the sequel—of the disease, and takes no part in promoting or retarding the destruction of the hard tissues. It is essential in the understanding of dental caries, to bear in mind the fact that inflammatory phenomena in the pulp and vascular connections of the teeth arise from, but do not give origin to or in any way influence, the destructive process in the hard tissues.

There need be no difficulty in believing that during progress of caries irritation may be communicated through the dentinal fibrils, and that, in some cases, the

stimulus may excite calcification of the pulp. This belief is sufficiently supported by the fact that an occurrence of this kind is very common where sound teeth, in the course of years, become worn down by attrition, until the level of the pulp chamber is reached. In these cases the pulp almost invariably becomes converted into dentine over the surface in danger of exposure; and the new-formed tissue coalesces with the surrounding dentine, and is evidently the result of a natural reparative effort. It is, however, very rare indeed to meet with protective calcification of this kind in caries. There are few, if any, specimens in the museum of the Odontological Society, and though, having this matter in view, Mr. Henry Sewill during several years examined a vast number of carious teeth in hospital practice, he never encountered a single example. It is very common to find isolated nodules of secondary dentine in the pulps of carious teeth, but such nodules are almost equally common after a certain age in teeth perfectly free from disease.

Cement in Caries.—Dental caries very rarely, if ever, has its starting place in cement, although the disease very often begins at the necks of teeth, in close contiguity to this tissue. Cement may become necrosed through stripping of its periosteum during inflammation, and the roughened surface, if exposed, at the neck of a tooth might, by giving lodgment to *dèbris* become destroyed, and so lead to caries of the underlying dentine. Cement, be it recollected, is identical in structure with bone, but it forms so thin a layer until the apex of the root is approached, that it has little effect in influencing or modifying the progress of caries. It must also be remembered that cement is capable of pathological activity, and any morbid phenomena which it displayed would not be analogous to caries in enamel and dentine.

Owing, no doubt, to the vitality of cement and its investing periosteum, decay advancing along the exterior of a tooth usually becomes checked at the border of this tissue. The walls of roots hollowed to the depths by decay thus often remain until the dentine within being nearly destroyed, the thin external shell enveloped and supported by the cement and its periosteum becomes gradually crushed in or broken down.

Spontaneous arrest of Caries.—Cases of spontaneous arrest of caries were alluded to further back, when it was implied that in rare instances the disease might come to an end without treatment. Such cases are of the following description:—The decay occasionally commences on the grinding surface of a tooth, the external portion of which alone is of inherently defective structure. The occurrence is most common in "honey-combed" teeth, particularly in the first permanent molars. The decay spreads over the whole of the ill-made enamel composing the masticating surface, which gradually breaks down until the denser, better-formed dentine beneath the defective tissue is laid bare. The surface so exposed being more or less used in mastication, constantly swept by the tongue and washed by saliva, becomes in time worn smooth and highly polished, and frequently endures for many years in that condition without any renewal of disease. The surface of dentine thus laid bare, shows, often from the first, little sensibility, and frequently becomes in time insensitive. It is possible that in these cases, as in the analogous condition produced by simple wearing down of the teeth from attrition alone, the pulp becomes calcified over the surface towards which the waste of tissue is progressing. It is not uncommon to find caries on the mesial and distal margins of "honeycombed" molars, in the situation where foreign particles lodge

on and within the pits of the defective enamel, whilst over the greater part of the masticating surface exposed to friction decay has become spontaneously arrested.

Epitome of Researches.—In accordance with the scheme of exposition, described at the opening of the chapter, a brief epitome will now be given of the authorities who have investigated dental caries. Many of the earlier investigators wrote at a time—not many years ago—when fermentation and putrefaction were believed to be purely chemical processes.

Sir J. Tomes.—It is now many years since Sir J. Tomes,* basing his investigations on the exact knowledge of the dental tissues which his previous researches had largely helped to establish, demonstrated very clearly and laid it down, "that caries is an effect of external causes, in which so-called 'vital' forces play no part; that it is to a great extent due to the solvent action of acids which have been generated by fermentation going on in the mouth, the buccal mucus probably having no small share in the matter; and when once the disintegrating process is established at some congenitally defective point, the accumulation of food and secretions in the cavity intensify the mischief by furnishing fresh supplies of acid." Sir J. Tomes, following Hunter, Fox, and Bell, was the first investigator to approach the task fully equipped with a knowledge of advancing physiological science—knowledge acquired largely by his personal labours, including study of the histogenesis and histology of enamel, dentine and bone. Sir J. Tomes' description of caries throughout was in all essential particulars correct, and needed only modification in the light of bacteriological science to bring it into harmony with present day knowledge. The essential correctness of

* System of Dental Surgery, 1859.

this description has been confirmed and never challenged by any investigator, unless apparently ignorant of or willing to ignore fundamental facts of physiology He showed that *all* the appearances of ordinary caries may be traced in the tissues of human teeth which have been inserted in the mouth on pivots or plates ; and, therefore, inasmuch as no characteristic appearances can be found to distinguish caries occurring in living from that in dead teeth, the hypothesis of vital action in any way modifying the disease must be abandoned *in toto*, and "dental caries cannot, strictly speaking, be said to have any 'pathology.'"

Sir J. Tomes regarded as the main predisposing cause of caries structural imperfections in the tissues ; and recognised that the physical signs visible at the onset of the disease vary mainly in consequence of the disintegration commencing sometimes on an unbroken surface, sometimes on a surface the seat of congenital defect. The other great predisposing cause is vitiation of the secretions of the mouth.

The mucous membrane, when irritated or inflamed, throws out an acid secretion capable of injuring susceptible teeth. He proved by experiment that this secretion is alone enough to give origin to caries. If a small pellet of cotton wool, or other foreign substance, be forced between two teeth, and left so as to press upon the gum, the secretion from the mucous membrane at that point will be found in the course of a few hours increased in quantity and strongly acid ; and it will be seen after a short time that the enamel of the adjacent teeth is undergoing slow solution.

Sir J. Tomes pointed to the fact that, in a superficial cavity subject to friction of mastication and swept by the tongue, decay will be slow, or may even be arrested, if the friction be made more thorough and constant, by

the breaking down of the low walls. On the other hand, the mere persistent retention of decomposing products in contiguity with the tissue, is enough to originate and keep up carious action. This he proved by experiment.

With regard to microscopical appearances, Sir J. Tomes compared carious enamel to enamel which has been slowly decalcified, but it is pigmented in a manner that cannot be imitated artificially. In the dentine he described as one of the earliest changes enlargement of the tubes, which become dilated to many times their original dimensions, and the parietes of the enlarged tubes having undergone partial decalcification, the so-called "tobacco-pipe" appearance is produced.

Magitot's researches* are interesting as foreshadowing future discoveries and presenting facts which, at the time, were inexplicable. He produced close imitation of caries by submitting teeth—sometimes protected at all but one part of their surface—to the action for prolonged periods of very dilute solutions of mineral and vegetable acids. He produced similar effects with fermentable solutions composed of sugar with organic matter. He incidentally proved that when an acid solution is kept from fermentation by the addition of an antiseptic, such as creosote, the enamel of an immersed tooth is entirely dissolved and the dentine gradually decalcified, but not entirely destroyed. We now know—what was not recognised at the date of these experiments—that the different results were due to the presence or absence of micro-organisms, the result being brought about in one case by chemical action, in the other by putrefaction and fermentation. Magitot held the opinion that caries is due to purely chemical action. He believed that he had produced experimentally in extracted teeth all the

* Traité de la Carie Dentaire, 1867.

phenomena of the disease except the zone of translucent dentine. He considered the zone indicative of vital reaction—an attempt at natural arrest of the disease by calcification of the dentinal fibrils.

Leber and Rottenstein's work,* written at a time when the study of bacteriology was in its infancy, formed a valuable and suggestive contribution, especially in directing attention to the development of one species of micro-organism in carious tissues, and to its effects in supplementing the action of acids. The initial stage of caries, they proved, is due to the solvent action of acid, and when a breach of substance has been produced, leptothrix penetrates into the interior of the tissues, and by proliferation, particularly in the dentine, occasions more rapid disintegration than would have been the case under the action of acid alone. They treated sections of dentine by staining with iodine, and demonstrated enlarged dental canals filled with what they described as minutely granular masses, composed of leptothrix and its developing elements. They clearly showed that masses of organisms proliferate within the canals and enlarge and distend them. They, in fact, described most of the phenomena which later discoveries have proved to be due to a great variety of bacteria, and they made a single mistake in classing all these as one species—leptothrix. They also proved that human teeth, artificially inserted in the mouth, and also teeth manufactured of ivory blocks, displayed when carious all the microscopic changes which earlier writers had regarded as proof of a vital process in dentine.

Leber and Rottenstein's illustrations of sections of carious tissue under low magnifying power, although somewhat diagrammatic, correctly represent the appearances.

* Caries der Zähne, 1867.

Professor Wedl, in his great work* on dental pathology, classed caries under the heading "Anomalies of the Secretions." Caries, he believed, has its origin chiefly in abnormal secretions of the gums, of the oral mucous membrane and salivary glands. He looked upon the secretion of the gums as most active, this secretion coming in immediate contact with and often forming a viscid covering on the teeth. In consequence of decomposition of the secretions, mingled with organic *débris*, acids are formed, which extract the calcareous salts from the hard tissues. The tissues are passive under this disintegrating process, and show no vital reaction, and no change whatever of an inflammatory character.

Wedl also noted that in certain conditions of health, such as pregnancy, there is an increased secretion from the gums of viscid mucus, which is frequently acid even without the presence of *débris* of food; and the action of this causes caries in many instances to assume a more or less acute character.

Wedl drew a clear distinction between dental caries and caries of bone, and pointed out why, on physiological grounds, a process of ulceration resembling caries of bone is impossible in enamel and dentine. The latter is an inflammatory process which originates in the soft parts of the bone and erodes its hard tissues. Dental caries, on the other hand, always commences in the hard tissues at a point furthest removed from the vessels, and spreads thence to the vascular pulp. The absence of acid (alleged by some observers) in some cases of well-marked chronic caries he disproves, and considers the

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* Pathologie der Zähne, 1870.

Professor Wedl, one of the most distinguished pathologists of the latter part of the 19th century, occupied the Chair of General Pathology in the University of Vienna.

absence of acid in any case of caries cannot be established. Wedl fully recognised the part played by inherent structural defects of the tissues, and especially dwells upon the occurrence of cracks or fissures in the enamel in connection with the development and extension of the disease.

It is interesting to note the accuracy of Wedl's observations, and to observe the truth of the drawings with which they are illustrated. Figs. 131 and 132 from his work may be compared with the photo-micrographs on another page (figs. 117 and 118), illustrating similar

FIG. 131.

conditions — inherent structural defects of enamel. Fig. 131 shows granular enamel with numerous minute pits at the surface. Fig. 132 shows a cavity in enamel, surrounded by solid tissue and communicating with the surface by a funnel-shaped depression, bordered by normal tissue. These are sections from teeth free from caries. Fig. 131 is × 400, fig. 132 is × 250, and these flaws would be therefore not recognisable by the unaided eye, to which the teeth would appear sound.

With regard to the minute phenomena occurring in the tissues in caries, Wedl observed in the enamel, as an early change, the presence of pigment of varying shade.

The persistence of the contours of the prisms in places that is, the more rapid solution of their centres than periphery by acid—he could not explain, but thought it possibly due to proliferation of a mass of leptothrix into the decalcified enamel. In the dentine he recognised two stages in the progress of the disease, which, however, could not always be nicely discriminated—a preparatory stage of decalcification and softening, and a stage of direct disintegration. During the latter stage the tubes become enlarged and varicose and filled with

FIG. 132.

leptothrix, which also he believed was to be found in all the ramifications of the carious cavity, although he had not discovered its presence in the earliest stages of the disease. Although Wedl, who also wrote before the science of bacteriology had far advanced, did not positively identify any form of micro-organism except leptothrix in carious dentine, he described the presence of minute bodies within the tubes, which he specifically referred to as highly suggestive of micrococci. It can hardly be doubted that these were really organisms of

that kind, the presence of which is now easily demonstrable.

Wedl pointed out that, although the living pulp does react against external agencies, still the interpretation of writers, according to whom an inflammation of the pulp can manifest itself by pathological effects in the dentine, is incorrect. Pursuing this subject further, Wedl clearly explained that irritation and inflammation of the pulp, when they occur during caries, form a sequel

FIG. 133.

to and are caused by destruction of dentine, and he showed that there are no grounds for ascribing changes in the dentinal filbrils to irritation of the pulp. The pulp seldom becomes implicated until the dentine has suffered a considerable loss of substance, and, indeed, in most cases is in no way affected until exposed to external irritation.

By an elaborate series of observations, completely illustrated by accurate drawings of the histological appearances of the tissues, Wedl conclusively demon-

strated that carious dentine of dead human teeth, and of artificial teeth made of ivory, presents the same appearances as are formed in ordinary caries, in respect of pigmentation, granular condition of dentinal fibrils, and thickening and varicose enlargement of the tubes. Figs. 133 and 134 may be taken as examples of these

FIG. 134

illustrations; these are sections of carious dentine × 500 from human incisors reinserted as artificial substitutes on a gold frame. Their accuracy may be gauged by comparison with the photo-micrographs on earlier pages. The difficulty of drawing and reproducing truthfully microscopical sections of this kind before the days of photo-micrography, was, of course extreme.

Messrs. Arthur Underwood and Milles. -To Messrs.

A. Underwood and Milles, of whose research* (commenced some four years earlier) the fruits were presented to the International Medical Congress in 1881, belongs the great credit of having been the first thoroughly to investigate the subject of caries in the light of the then recently-established knowledge of the true nature of the processes of fermentation and putrefaction. They pointed out that although the old "vital" theory—the theory that caries is a real disease, a pathological process due to causes acting from within —had been abundantly disproved, yet the chemical theory—the theory which supposes mere solution of the tissues by acid—could not be considered wholly satisfactory. They proved that destruction of teeth by action of acids, without the aid of septic agents, does not result in producing naked eye appearances or minute tissue changes exactly like those occurring in true caries. Sections of dentine so decalcified show disappearance of the matrix, but not enlargement of the tubules, and there is an absence of pigmentation throughout. They repeated and confirmed the experiment first performed by Magitôt, who, however, at the date of his investigations could not, of course, account for the result—the experiment which proves that it is impossible to produce artificially caries resembling natural caries when septic influences are excluded. They from this assumed that two factors are in operation in caries—the action of acids and the action of germs. Their theory they put forth rather as an amplification of the chemical theory than a contradiction. The work of decalcification, they proved, is entirely performed by acids, but the acids are generated by germs, which, as is now known, are essential to the processes of putrefaction and

* Transactions International Congress, 1881.

fermentation. These considerations led the investigators next to seek for the presence of organisms in carious dentine. They cut a vast number of sections from fresh carious teeth immediately after extraction without use of any softening or decalcifying reagent, and subsequently stained them with an aniline dye—methyl violet. Examination of these preparations under a one-eighth lens disclosed the fact that the tubes were

FIG. 135.

invariably infiltrated with organisms, for the most part micrococci and oval and rod-shaped bacteria. The accompanying diagrams (figs. 135, 136 and 137),* from the *Proceedings of the International Medical Congress*, 1881, may help to show how clearly these observers described the morbid anatomy of caries. These figures, showing longitudinal and transverse sections of dentine

* Owing to a mistake of the draughtsman the rods in these diagrams are epicted with square instead of rounded ends.

in an advanced stage of decay, should be compared with the photo-micrographs on earlier pages, figs. 124, 125, 127 and 128.

In decay in blocks of hippopotamus ivory worn on a plate, they observed similar appearances. These observers also made a large number of experiments and established important facts. In teeth exposed to the action of weak acid with perfecty aseptic conditions,

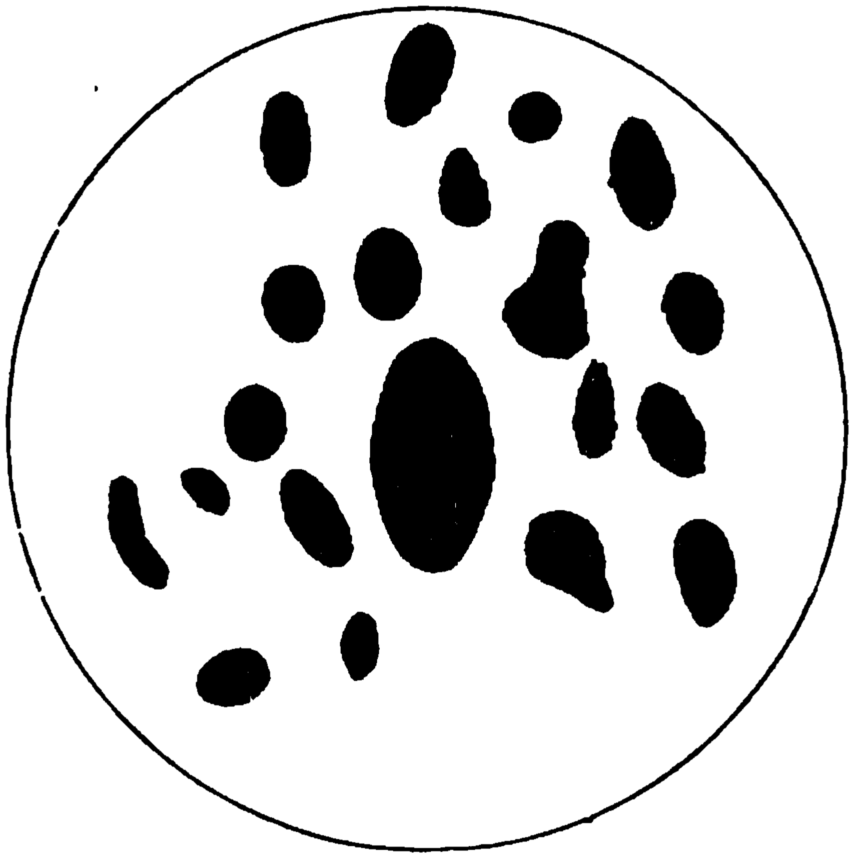
FIG. 136.

solution of enamel went on so long as the acid was unexhausted and then ceased. On the other hand, where extracted teeth were exposed to septic influences immersed in organic *débris* such as exists in the mouth, the action of the organisms ("which constitute a living factory of acid") caused gradual decalcification of the whole tooth and destruction of the organic basis of dentine, the microscopical appearances very closely resembling those of natural caries.

Mr. Underwood has shown that the "tobacco-pipe" appearance is not peculiar to caries, but is to be seen whenever a re-agent renders prominent the sheaths of Neumann.

By a simple experiment-cultivation of organisms derived from carious dentine, Mr. Underwood also demonstrated the fact that organisms cause the characteristic pigmentation of caries—several varieties of

FIG. 137.



organisms produce special colours, some black, some brown, some green.

Professor Miller,* of Berlin, was the first investigator to follow the lines traversed by Messrs. Underwood and Milles. Dr. Miller first traced the derivation of the acid, the prime agent in caries. He demonstrated the presence in the mouth of an acid-forming ferment of organic origin, and obtained a pure culture of the active

* Organisms of the Mouth, 1889

organisms. He showed that these organisms, added to a fermentable mixture, gave rise within a few hours to formation of acid capable of decalcifying enamel and dentine.

By a series of experiments in production of caries artificially, Professor Miller carried investigation in this direction further than Messrs. Underwood and Milles. Tubes containing sterilised starch solution were attached to teeth within the mouth, access of saliva being allowed, and were left for six or eight hours. At the end of that time the contents of the tubes were found to display strong acid reaction, and this was easily proved to be due to fermentation with the presence of bacteria. By similar methods applied to dead teeth out of the mouth, Dr. Miller has produced artificial caries which cannot be distinguished by the microscope from true caries.

In a more recent communication,* Dr. Miller has returned to the subject of the so-called transparent zone —the zone of slightly more translucent dentine, which is found surrounding the cavity of decay. He affirms that the zone does not appear in dead teeth; that it appears in teeth in which the action of acid from without appears to be excluded; that chemical analysis does not bear out the decalcification theory, and finally that the action of colouring matter upon the zone is not what we should expect if partial decalcification had taken place.

Dr. Miller, it seems, merely records these facts; he draws no deduction from them.†

* Trans. Odont. Soc., 1895.

† Dr. Miller's observations are in direct conflict with the testimony of many unimpeachable investigators, beginning with Sir J. Tomes, who was the first to describe the "zone" and who (as we have seen) declared that all the phenomena of caries are visible in dead teeth. But assuming the correctness of Dr. Miller's observations, it would be very easy to ascribe more practical importance to them than they deserve. Let it first be borne in mind that the zone, the altered

Messrs. Pound and Henry Sewill.—Messrs. Pound and H. Sewill were engaged during the years 1889, 1890 and 1891, in an investigation of caries. Their work was published in a paper on the "Artificial Production of Dental Caries," and in several minor communications during those years.* Many hundreds of sections of carious teeth were cut, stained and examined. The result of this work was confirmation of the correctness of the descriptions of the bacteriology of caries, as previously explained by Messrs. Underwood and Milles, and by Dr. Miller. The photographs in this chapter (those not ascribed to other authors) illustrate typical examples of Mr. Pounds' sections.† Messrs. Pound and Sewill were able once more to demonstrate the fact that caries in a human tooth, re-inserted in the mouth as an artificial substitute, is identical in every essential respect with that in living teeth.

Attempts at the production of caries artificially in extracted teeth were commenced early in 1890; in June, 1891 a successful result was reported to the Odontological Society.

It was found that with the exception of leptothrix, which will not flourish away from its proper *habitat*, all organisms present in caries could be cultivated, either

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character of which merely consists of slightly increased translucency, is visible only under low magnifying powers. The altered dentine under higher and the highest powers exhibits no structural change whatever; and this is not surprising when it is remembered that the calcareous and fibrous basis of the tissue contains no physiological elements capable of intrinsic alteration. The tubes throughout the zone show usually the common appearances of incipient caries; they have not yet become generally enlarged, but are often occupied by a line of organisms, with apparent obliteration of the fibrils. Through the fibrils alone could be conveyed or communicated any influence from within; with their destruction ceases the faintest possibility of vital reaction of any kind within the tissue.

* Trans. Odont. Soc., 1889, 1890 and 1891.

† These sections were photographed from the microscope by Mr. Andrew Pringle, and were the first of their kind published.

together or isolated, out of the mouth; and the problem thus resolved itself into creation out of the mouth of conditions sufficiently like those existing within, so that teeth submitted to the influences would undergo those distinctive changes which constitute the process termed dental caries. After trying various mixtures of organic substances, it was found that the best for the purpose was bread mixed with saliva. The proportions did not seem to matter, but one part bread to eight of saliva answered well. Some failures with other substances are significant and may be mentioned. Meat with saliva remained alkaline, and if a small quantity of acid were added became again rapidly alkaline; and albumen, whether as white of egg or other forms acted in the same way. Saliva and starch produced little acid which was soon exhausted.

The teeth were immersed in the mixture—several in each ounce—in stoppered bottles, and kept at a temperature of about 35° to 37° C. = 94° to 98° F. The bottles were unstopped for examination and to admit air about once a day. The mixture sometimes became putrid when it at once showed an alkaline reaction. The teeth were then taken out, well washed, and the mixture renewed. The mixture became rapidly acid, and remained so (unless putrefaction supervened) for from three to five weeks. The acids present were acetic and lactic; and of the former 5 per cent. and of the latter ·5 per cent. were found after three weeks.

The effects upon the tissues both macroscopical and microscopical were precisely the same as in natural caries. A tooth wholly immersed was, of course, attacked all over at once, but disintegration advanced more rapidly through mechanical flaws or inherent fissures in the enamel; and where such flaws allowed easy access to dentine decay progressed more rapidly in

that tissue than in the enamel. The enamel became undermined and extensive pigmentation and discolouration commonly took place.

The experiments went to show that the incidence of the disease is governed largely by the presence of inherent defects in the enamel; and that the rapidity of the disintegrating action is mainly governed by the structural qualities of the tissue. The experiments were mostly made upon sound teeth; but it was found that with carious teeth decay continued, and if the cavity were previously excavated decay attacked first at that point and advanced most rapidly through the exposed dentine.

The phenomena attending the invasion of organisms and their proliferation along the tubes differed in no respect from natural caries.

The "transparent zone" and "pipe-stem" appearance were visible, as well as that appearance previously described resembling "pipe stems" in vertical section.*

The artificial production of caries may be perhaps considered the crucial experiment by which the last shreds of doubt as to the essential character of the disease must be destroyed. It is an experiment, which, needing no apparatus except an incubator, or other means to maintain uniform temperature, can be easily carried out, and there seems no reason why it should not be performed by students at every dental school as an exercise to impress the facts upon the memory. To help

* A series of sections showing all these appearances were exhibited at the Odotological Society in June, 1891, and presented to the Society. The sections were prepared by first staining with aniline violet. The colour was then fixed in the organisms by treatment with iodine—potassic iodide solution. To show tissue changes the sections were then stained with orange rubin, the previous colouring having been first washed out by spirit. This stain differentiated the altered tissue. Unaffected dentine appeared deep red, the "zone" faint pink, "pipe stems" red with lighter centres, and dentine in last stage of softening light yellow.

such experimentation has here been kept in view in giving a sufficiently full description of Messrs. Pound and Sewill's work.

Dr. Leon Williams.—Dr. Leon Williams' writings* have already been freely drawn upon in explaining the histology of enamel, and in describing the phenomena of caries. Dr. Williams stands foremost among those who have demonstrated and placed beyond controversy the fact that normal enamel is completely calcified, and contains no trace of organic matter; and that no physiological change is possible in the completely formed tissue. He has proved that "enamel is a solid mineral substance, and that the finest lenses reveal not the slightest difference between enamel ground moist from a living tooth, and that which has laid in the earth for a hundred centuries."†

Dr. Williams has traced out more thoroughly than any other observer the minute phenomena of caries in enamel, and has illustrated his papers by the most elaborate and consecutive series of photo-micrographs

* Transacs. Royal Society, 1895. Dental Cosmos, 1897. Journal Royal Micros. Society, 1897.

† Note by Mr. Henry Sewill.—"With infinite pains Dr. Leon Williams has established this thesis by tracing out the histogenesis as well as demonstrating the structure of the tissue under high microscopical powers. A simple experiment seems, however, alone enough to satisfy an ordinary mind on this point. Enamel is soluble in acids so weak that they could not destroy nor materially alter organic elements. After such solution—which may be rapidly carried out with thin sections—it is never possible to distinguish by ordinary visual or other tests any trace of organic structure. Such a trace is only to be discovered in some few instances by minute chemical analysis; and it is evident that if such a trace were distributed throughout the tissue, it must be in a condition of tenuity so fine as to be inappreciable.

Advance in the art of photo-micrography within late years has made it possible to appraise the value of the work of investigators whose researches are illustrated by this means. In former days the microscopic image could be reproduced only by drawing. An artist had to be employed, who very often was unable to grasp the meaning of what he saw; or the investigator had to undertake the drawing himself, and frequently failed from want of skill. In any case it was impossible to eliminate the personal equation, and reproductions from the

hitherto produced under all powers up to the highest. He ground more than four hundred sections of enamel in every stage of decay. In one respect every specimen showed precisely the same appearance. Lining the cavities or covering the surface where decay had commenced there was always to be seen a thick felt-like mass of acid-forming micro-organisms. This mass of fungi was so dense and adhesive as to make it highly improbable that the enamel was affected, except in rare or special instances, by any acid other than that which was being excreted by the bacteria at the very point where they were attached to the enamel. The thick mass of fungi also prevents the excreted acid from being washed away, and so it exerts its full chemical power upon the tissue.

The appearances of enamel at the commencement of decay are very strikingly shown in fig. 120, from a section of a lower bicuspid from the mouth of a woman thirty-five years of age, who had suffered but little from caries, although the teeth had been poorly cared for. The patient returned after a year and a half with the teeth in a very bad condition. A marked change in systemic health was noted, and the traces of acid fermentation in the mouth were very evident. On both sides of the lower jaw the second bicuspid and first molar were decayed beyond the possibility of restoration. The

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microscope in many instances represented rather the fancy of the observer than the exact image beneath the object glass. Photography cannot completely fail in such respects; and although even the best photograph, direct from the microscope, may not always give the vivid impression which the eye receives when viewing a thin section under high power, still it affords the experienced microscopist almost as much information. On a former page reference was made to the complete demonstration of the histology of enamel, which Dr. Leon Williams' series of photo-micrographs had afforded; and the same must be said of those he has published—very numerous, and many of them under high powers—illustrating experimental decalcification, as well as all the phases of caries in enamel. These photographs seem to put beyond doubt the substantial correctness of Dr. Williams' account of the phenomena of caries in this tissue."

remains of these teeth were removed preparatory to making a plate, and as the first bicuspid on one side stood outside of the arch, and at an angle which would have interfered with the fit of the proposed plate this was removed also. Although somewhat stained, it appeared to be perfectly sound. A section of it was afterwards ground. The tooth, which was without opposing teeth in the upper jaw, was literally covered with a thick growth of micro-organisms. The acid products of these fungi had softened the entire crown of the tooth in several places, penetrating both enamel and dentine, although there was not a trace of a cavity to be seen on the external surface.

Examination of the spot on the approximal surface, shown in fig. 120, under a higher magnifying power, revealed the fact, that while there was no actual breaking down of tissue on the surface, yet the destructive agent, which had caused discolouration and penetrated the entire thickness of the enamel, had produced a cavity of considerable dimensions at the line of union of the dentine and enamel. Under still higher power it was found that the cavity on the border of the dentine was partly filled with loose and decomposing particles of enamel. An acid, for nothing else could have produced this effect, had penetrated the enamel and accumulated in some congenitally defective spot, at the line of union of the tissues where such places are most frequently found, and had enlarged what was probably but a microscopic area at the beginning into a cavity of sufficient size to be seen by the unaided eye after grinding the section. Examination of the section in any part of the stained area, showed that the cement-substance which united the enamel rods had been dissolved out until canals of considerable size had been formed between the rods. Down the canals thus

formed the acid had penetrated to the cavity beneath. Experiments on sections of sound enamel out of the mouth showed that effects substantially identical with those seen in the specimens could be produced by the action of acids, the first action of the acids being to separate the rods, and, usually, also the globular bodies or sections of which the rods are composed, by solution of the cement-substance.

The condition of the tooth shown in fig. 120, gives a most complete explanation of what has been wrongly intrepreted as a retrograde metamorphosis of enamel. We see that the change which has been thus interpreted is entirely caused by an agent penetrating from without. Dr. Williams points out that if the real cause of the softening of enamel, so often observed, had formerly been known, thousands of patients would have been spared the annoyance and often the injury of being treated with phosphates and phosphatic foods in the belief that such treatment would improve and harden the enamel of their teeth.

Opposing Theories.*—Theories which have been set forth, either in earlier or recent times, and which would,

* Note by Mr. Henry Sewill.—"In a previous work (Dental Caries, second edition, 1888) I examined exhaustively all the theories which go counter to the explanation of caries set forth in this book. The authors were extensively cited; and the quotations were, I believe, alone enough to show the worthlessness, as well from a literary as from a scientific standpoint, of most of the writings. There exists altogether an enormous mass of literature] upon the subject; but the greater part of the best of this mass, when not made up of purely fanciful hypothesis, consists mainly of the record of merely superficial 'impressions, without foundation of demonstrable fact or support of logical reasoning. It was, I think, clearly shown in my book, that there had been written on the subject of dental caries probably more nonsense than on any other single subject in the whole range of human pathology. Many of the essays, as I proved by quotation, were in great part unintelligible, owing to introduction of new and unrecognised pseudo-scientific phraseology, and to disregard of the elementary rules of common grammar. It might have been expected that the advance in dental physiology within late years, which has established beyond controversy the histological characters of the tissues, and has opposed an absolute negative to any but the one explanation of the essential nature of dental caries,

if proved, show the falsity in part or entirely of the views set forth in this work, may be divided into three categories: First, those that would make out caries to be a true disease, carried on by pathological action initiated within the tissues; second, those admitting the disintegration of enamel and dentine to be due to external agents, but insisting that these agents are powerless without prior occurrence of morbid changes in the tissues, which lessen their power of resistance and predispose them to attack; and thirdly, theories which admit that caries is entirely due to external agents, but maintain that the tissues—or at least dentine—are not passive under the process of disintegration, and assert that the process is accompanied by inflammatory phenomena, or some kind of vital reaction. No modern author has been bold enough to support the first of these theories in its entirety. This view is confined almost exclusively to obsolete works composed before the anatomy of the teeth had been clearly made out, or their physiology properly understood.

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would have led to the final setting aside of such fantastic performances. This has, however, not been the case. It is still not uncommon to find pseudo-scientific utterances, such as I have characterised, quoted side by side with the work of unimpeachable authorities, and without any suggestion as to their questionable value. It is, however, true that in many cases authors—some British, some American—have evidently been influenced by a fellow feeling, which has made them kind, for they themselves, in their most important pages, print passage after passage the meaning of which can be barely guessed by an expert, so persistently and consistently ignored are the indispensable rules of syntax and etymology. It is more astonishing to find quotations of this character in at least a few standard works of the day, without any hint at the intrinsic evidence of the worthlessness of the cited writings. Such treatment of the subject cannot fail to bewilder the ingenuous student; and it is for the sake of this class of readers that it has been thought necessary, in this, as it was in the third edition, to notice from the authors referred to, such arguments as can be put into intelligible shape; so that the student may gauge their value for himself, and not imagine (as he otherwise might), that they had been passed over because unanswerable. This explanation may subserve the purpose of an apology to advanced students and to scientific readers, who may probably consider that, for them, the demonstration of the nature of caries has in these pages been somewhat over-laboured."

Regarded in the light of modern science, the opinions of the early dental pathologists are not more absurd than those of workers in other departments. It was first necessary, before exact knowledge of disease could be obtained, that complete acquaintance with the structure of the tissues in health should be gained ; and this was impossible before the perfection of methods of histological investigation. It was natural for old writers, ignorant of the real structure of enamel and dentine, to look upon these tissues as more highly organised than we now know them to be ; to speak of their "vitality," to suppose that they underwent constant nutritive changes ; to identify the phenomena which disease made visible in the tissues with similar effects in more highly organised parts, and to classify these appearances as inflammation, ulceration, atrophy and gangrene—conditions to which they, perhaps, bore a superficial resemblance.

It would be probably in most cases very unsafe to try to establish on *à priori* grounds alone the truth of an explanation of any series of morbid phenomena. But if the conclusive mass of evidence (set forth in previous pages) derived from observation and experiment did not exist, an argument based on consideration of the anatomy and physiology of enamel and dentine would alone suffice to prove that caries could be due only to external agents.

The student cannot have failed to perceive that enamel and dentine are anatomically quite peculiar, and are not closely comparable to any other human tissues. In their physical and chemical characters they most closely resemble dense bone ; but even the densest bone is permeated by a free vascular supply, while these have none. Between them and other avascular structures, such, for example, as cartilage and the cornea, there is

the vast difference that the latter are largely composed of cells and protoplasmic elements, and are capable of carrying on physiological processes and of undergoing intrinsic degenerative and reparative changes.

Enamel is totally devoid of any elements whereby physiological changes could be brought about in it. A tissue incapable of physiological activity cannot become the seat of true pathological change. Not only is enamel incapable of intrinsic physiological changes, but it is not in relation with any physiological organisation capable of acting upon it from within. To believe in the possibility of physiological activity in enamel, we must first believe that it contains the necessary elements, and next conceive some means by which the calcareous basis could assimilate nutritive material when conveyed to it; and we must then imagine the conveyance of new and effete material by way of the dentinal fibrils to and from the vessels of the pulp. To dentine the tissue with which alone enamel has relation similar remarks apply with almost equal force. The great bulk of dentine is composed of a homogeneous calcareous matrix investing a dense fibrous framework, in which no trace of active cellular or other living structure can be detected. It is a tissue in which the minute fibrils alone can be said to possess any "vitality."

Structures constantly undergoing physiological changes contain tissue elements whose activity is demonstrable. They require for their maintenance in health a proper supply of nutritive material from the blood, as well as provision for removal of effete material. It is from failure or perversion of necessary physiological activity of this kind, and by this means alone, that parts can be brought into a state predisposing them to disease, or actual pathological change can be produced in them. We have only first to think of the anatomy of a tooth as

a whole, and of that of enamel and dentine in particular, and more especially to think of the structure of enamel —the starting place of caries—and then to realise the nature of the physiological factors necessary in the production of mal-nutrition or impaired vitality leading to pathological change—we have only to bring these things vividly before our minds to perceive the absurdity of a belief in the possibility of such morbid processes originating in enamel.

It is beyond all things necessary, before adoption of any theory, that its foundations should be proved absolutely secure; and, as pathology must have its basis on anatomy and physiology, it is evident that no apparent pathological phenomenon irreconcilable with incontrovertible facts of those sciences can be accepted as real. On physiological grounds alone we should be justified in rejecting as absurd any suggestion that pathological phenomena as they occur in vascular and avascular structures elsewhere in the body could be discovered in enamel or in the hard fibro-calcareous mass of dentine.

The account of caries given in this work starts from the established anatomical facts which are set forth in the opening chapters, and it has been recognised by the better class of recent writers, who have brought forward arguments in opposition, that it would be necessary to overthrow those facts before a new theory could be founded. An attempt to do this has been made. An American observer stated some years ago that by staining the tissue with chloride of gold he had demonstrated the presence of active organic matter regularly distributed between the enamel fibres. And this observation has been held by some writers to prove the possibility of physiological and pathological activity in enamel. The difficulties in believing in the necessary

nutrition of physiological elements in enamel, if we could suppose them present there, have been already dwelt upon.

Gallippe and Hoppe-Seyler made some observations going to show that teeth (enamel and dentine) increase in density as age advances; but these observations are incomplete and fallacious, and it would be unsafe to base conclusions upon them. Since individual teeth of a set in the vast majority of cases vary considerably in structural character, it would be necessary in order to prove alteration in density to cut sections from the same tooth at different periods of its existence. But even this experiment would not be conclusive, for as we have seen, the original density of different portions of a tooth may vary very much. The result of the experiment would be determined in accordance with the innate structural characters of the tooth. At one part it might yield enamel and dentine of the densest quality, at another it might yield tissue less dense owing to the presence of defective strata such as have been described on a previous page.

An experiment which every dental surgeon performs in practice daily is without any other evidence almost alone enough to prove that not only enamel but also dentine is too lowly organised to be capable of physiological action. This experiment consists of the common operation of filling or stopping teeth. It cannot be believed that tissues so highly organised as the hypothesis in question supposes would passively tolerate the presence of a foreign body like a mass of gold or other stopping forcibly wedged into their substance.

Relying upon the undoubted clinical fact that caries is very often started or accelerated during morbid states of the system, not accepting as sufficient the effects of the predisposing causes described in previous pages, and

disregarding the experimental and clinical facts which negative the hypothesis, some writers have argued that caries must be influenced by causes acting from within. It has been already explained that all the phenomena of caries, including appearances visible to the naked eye and those disclosed by the microscope, are to be observed not only in pulpless teeth and in dead teeth replaced in the mouth as artificial substitutes, but also in blocks of ivory used for the same purpose. And not only is this the fact, but the remote as well as direct causes of decay in these dead substances when worn in the mouth are precisely the same as govern the onset of caries in living teeth—teeth with living pulps and living periosteum. Dead teeth and ivory blocks are under similar conditions neither more nor less liable to decay in the mouth than their neighbours implanted in the alveoli. Some years ago, before the general use of vulcanite, artificial teeth were much more frequently constructed of gold plates with human teeth mounted upon them, and it was a fact of common observation—one which every dentist was able fully to verify—that the durability of this kind of work varied very much in different individuals and under changing circumstances in the same individual. Every dentist recognised that their durability depended very largely upon the quality of the enamel and ivory of teeth and blocks employed; if these were of the most solid structure they lasted much longer than if inherently weak. Their durability depended, secondly, on the health and personal habits of the wearer. In a mouth habitually neglected and where the frames were allowed to remain for long periods coated with decomposing *débris,* the teeth and blocks were speedily softened and destroyed, whilst on the other hand where the mouth and teeth were kept scrupulously clean the beginning of decay was relatively less frequent and its

progress in like degree less rapid. A combination of bad health with neglect, giving rise to extreme vitiation of the buccal secretions, was with certainty accompanied by destruction of the artificial teeth. It was proved, moreover, that when such dead teeth were attacked by caries decay began precisely in those situations where it would be most likely to attack a living organ—namely, in places favourable to the lodgement of decomposing particles, and on surfaces where a solution of continuity allowed access to exposed dentine; and that if cut surfaces were finely polished, so as not to allow the ready adhesion of *débris*, these surfaces would, like those of a living tooth under similar circumstances, be much less liable to decay. In short it was amply proved that disturbances of the general health and local conditions exercised the same indirect influence upon ivory blocks as upon living teeth, and the effects were traceable onwards through the same series of events, namely, vitiation of the buccal secretions and putrefaction and fermentation of organic matter attended by development of micro-organisms, and formation of acids in the vicinity and on the surfaces of the teeth.

It has been further already explained that caries in every essential character identical with the disease in living teeth can be produced out of the mouth by artificial means in extracted teeth. To all this must be added the fact that no observer has ever produced a specimen of enamel and dentine in which degenerative changes were present. If in some systemic states teeth were to undergo softening or degeneration, owing to abstraction of their solid constituents through the vascular system, the morbid process would surely begin, if not always, at least very often on the surface nearest the vessels—in the dentine forming the walls of the pulp cavity. No such appearances have ever been detected,

but on the contrary, where softening or disintegration of a tooth takes place, it is always progressive from the external surface, the situation where agencies exist capable of producing the effects.

Some writers dwell much upon the occurrence of what they style acute caries, associated with general ill-health. A very common example is seen in patients, subjects of long-standing chlorosis. A set of delicate teeth extensively filled, which have gone on without serious outbreak of decay from late childhood till beyond puberty, in such cases often suddenly show renewed signs of general decay; well-made stoppings fail, and tooth after tooth is attacked by rapid caries. Precisely the same thing is often seen in women with delicate teeth during the child-bearing period. It must be recollected that a cause, however slight, if in action sufficiently long, is enough to account for great effects; and ill-made enamel from the moment of a tooth's eruption is exposed to the constant or intermittent action of destructive agents.

These cases of acute caries are fully accounted for by the action of the predisposing causes which have been discussed, and may be safely ascribed first to presence of innate structural defects in the tissues; and secondly, to gradual solution of weak enamel by acid. It is to be easily understood that, in the course of months or years patches of ill-made porous enamel become further weakened by gradual solution and allow readier access of acid-forming products, even into the substance of the tissue. Given such extensive areas of organically weak tissue, allowing infiltration of fluid and undergoing slow solution, and we can understand that a change in health involving vitiation of the secretions of the mouth and encouraging formation of acid, should often be accompanied by rapid breaking down of the previously

weakened enamel. Enamel inherently defective often covers dentine of equally bad formation ; and the enamel of ill-made teeth once penetrated by caries, the rapid destruction of the soft imperfectly calcified dentine which often follows need excite no astonishment. These phenomena of slow penetration, solution and destruction of enamel and dentine by acids and organisms have been followed and demonstrated by numerous observers, as explained on previous pages.

The student conversant with the nature of inflammatory action—with the objective phenomena and the subjective symptoms which are comprised in the term inflammation—can hardly have failed to perceive that the physiological facts just discussed suffice to prove the impossibility of the occurrence of vital reaction of the nature of inflammation in dentine. The following facts may be recapitulated : Caries never commences in proximity to the vessels (on the walls of the pulp chamber), but always at the external surface, the point furthest removed from vascular influence ; signs of inflammation, which invariably arise speedily in vessels bordering avascular tissues the seat of inflammation, are absent in caries ; there are no tissue elements in dentine except the fibrils, which are capable of interstitial change ; caries goes on unaltered and with precisely the same microscopical appearances when the pulp and therefore the fibrils are dead. If inflammatory corpuscles are present in carious dentine they must arrive there by traversing intervening dentine by way of the tubes from the vessels of the pulp—a supposition which is manifestly absurd.

The errors of the few older although modern observers, who have believed in occurrence of inflammation in caries, arose from misinterpretation of the significance of apparent changes in the tissues. The masses of

organisms, for instance, in the dilated tubes of carious dentine readily taking up colour might possibly be mistaken for inflammatory corpuscles by observers writing at a period before the existence of micro-organisms was suspected in such a situation, and before their real nature had been ascertained.

It is scarcely credible, but nevertheless true, that in face of all facts and considerations an American writer within late years has elaborately described what he styles inflammation of enamel and inflammation of dentine, and has described the constant presence in carious dentine of "nodulated protoplasmic bodies with nuclei and threads running from one to another," and states that in his judgment "it is this living matter which has been mistaken for organisms."*

The publication of a statement of this kind seems hardly compatible with possession of an adequate knowledge of microscopical and bacteriological science, for not only are the tubes in caries filled with organisms and only with organisms, the forms of which are perfectly familiar to all competent observers, but each and all of them (except leptothrix, which will not grow transplanted from its peculiar habitat) can be separated, isolated and cultivated out of the mouth by the method now commonly practised by bacteriologists. By the performance of this simple yet crucial experiment this writer might have convinced himself of the falsity of his observation.

* Note by Mr. Henry Sewill.—"This author must be taken as a fair sample of the class of writers alluded to at the opening of this section in a previous note; and his statement may be regarded as a specimen of the kind of fact upon which theories have been based, and then set out before students with a show of authority. This author belongs to what is sometimes spoken of as a 'school' of investigators, who pin their faith on the exploded fallacy that enamel contains active organic elements. In spite of complete demonstration of their fundamental falsity the views of this 'school' have been iterated and reiterated with such pertinacity that this alone seems to have sufficed to ensure their adoption by writers of a certain class, and their citation by others who ought to know better."

Relative Frequency of Caries in different Classes of Teeth.—It is a remarkable fact, and one that has some practical application (as was seen in the chapter on Irregularities), that the teeth are not all equally liable to be affected by caries. Series of cases have been tabulated from time to time by various observers, and these agree in the main with each other.

The following statistics of 10,000 cases, collected by Magitôt, show the relative frequency of caries in the different kinds of permanent teeth.

Central incisors	642	Superior	612
		Inferior	30
Lateral incisors	777	Superior	747
		Inferior	30
Canines	515	Superior	445
		Inferior	70
First bicuspids	1310	Superior	940
		Inferior	370
Second bicuspids	1310	Superior	810
		Inferior	500
First molars	3350	Superior	1540
		Inferior	1810
Second molars	1736	Superior	690
		Inferior	1046
Third molars	360	Superior	220
		Inferior	140
	10,000		10,000

The first point which attracts attention in these tables is the great relative frequency of caries in the first molars; the next, the much greater frequency of the disease in the front teeth of the upper than in those of the lower jaw. The latter circumstance may, perhaps, be partly accounted for by the fact that the lower front teeth are protected from the action of acid by the saliva

with which, owing to their position, they are constantly bathed. It must, however, be admitted that no entirely satisfactory explanation of the ratio of frequency in the several classes of teeth has yet been afforded. The localisation and the incidence of caries are certainly determined, to a great extent, by the presence of inherent flaws in the enamel of the teeth attacked; but, although our knowledge of the causation of dental hypoplasia has extended during late years, we cannot yet fully account for the fact that certain classes of teeth are more than others the seat of these defects.

Diagnosis of Caries. — The diagnosis of caries is usually simple. In a considerable proportion of cases patients are aware at an early stage of the disease that a tooth is affected, and more especially where food is apt to lodge in the cavity during mastication, or when decay begins on a part exposed to exploration by the tongue, which quickly perceives a roughened surface. But as many cavities are hidden, either under the free edge of the gum or in interstitial situations; as caries of enamel is unattended with pain, and as neither exposed dentine nor exposed pulp is invariably accompanied by pain, it is impossible without careful examination of the teeth, to be sure that caries is not active in a mouth. For this purpose mouth mirrors and dental searching probes are needed. The probes are thin and needle-pointed, and bent in curves to pass round the contours of the teeth. In examining a mouth for caries each tooth should be separately explored; its fully exposed surfaces, the neck under the free edge of the gum, and the mesial and distal aspects. In these latter places the greatest care is often required: the fingers are apt to be deceived; small cavities are easily overlooked, or on the other hand, a deposit of tartar, or some other accidental roughness of outline, particularly along the neck of the

tooth, may give a false impression of the existence of caries.

In incipient caries of enamel the only signs frequently are slight roughness, amounting to no more than loss of polish and slight softening or friability, together with change of colour. The friability is to be distinguished by cautious use of a fine-pointed steel probe, an instrument which will glide over a polished surface, but will convey the impression of roughness and porosity when either of these conditions prevails. The colour change most often consists merely of whiteness and opacity; but pigmentation in varying shades of brown and black is also often exhibited.

In some few cases, to facilitate examination of surfaces in very close apposition, it is a very good plan to press teeth apart by one or other of the methods described in a later chapter. The electric light, in the form of a miniature incandescent lamp held within the mouth, which is now so commonly employed in dentistry, is occasionally a useful aid in diagnosis. It renders the teeth semi-transparent and discloses discoloured surfaces in hidden situations.

Some appearances on the surface of the teeth and conditions of enamel which simulate caries, are occasionally met with; it is important they should not be mistaken for decay. Patches of enamel of a yellow colour, or of a white or opalescent hue, differing from the shade of the rest of the tooth, are not infrequently met with as innate structural markings on perfectly sound tissue free from other blemish. These marks are to be distinguished by their hardness and polish and by the absence of other signs of caries. When on the labial aspect of front teeth, the existence of these markings is often well known to patients, who are aware the spots have remained unchanged since the eruption of the

teeth. Thin layers of hard black or brown tartar often simulate incipient caries; careful examination will of course show the real nature of the case.

Discoloured pits and fissures, not the seat of decay, may be mistaken for carious cavities. In teeth of the most delicate structure, and in mouths where caries begins early in life and attacks many of the set, it becomes sometimes a question especially when the patient is not kept under frequent observation, whether it may not be better to anticipate the onset of decay, and prepare and fill all fissures, whether carious or not, which give a lodgment to decomposing *débris*. Such a procedure would be quite unjustifiable in dealing with a set of strong teeth little affected by caries.

The depths of the sulci between the cusps of molars and bicuspids are in a large proportion of teeth, the enamel of which is of first-rate quality, more or less stained, and often have the appearance of decay By careful exploration with a sharp-pointed probe it may be ascertained whether softening exists. Such discoloured lines often endure through life free from decay—sometimes they become gradually obliterated as the surface is worn by mastication. Every now and again, in one or another tooth, a fissure or a pit with smooth rounded walls will be found which is evidently merely a depression in the contour of the tooth, being covered with dense polished enamel, although very often discoloured by deposit of tartar. Pits in "honeycombed" teeth are often of this character, and do not then call for immediate treatment.

PREVENTION OF CARIES.

THE remote or pre-disposing causes of caries, which have been fully described in previous pages, are (1) innate structural weakness and defects in enamel; (2) vitiation of the buccal secretions; (3) crowding and irregularity of the teeth. The immediate cause of caries is the lodgment of acid, or of acid-forming micro-organisms and *débris*, on the surface of the teeth or within defective spots—pits and fissures—inherent in the enamel. The prophylaxis of caries must be based on prevention of these causes.

The origination of ill-made dental tissues is a large subject, which cannot be more than touched upon in this work.

There is gradual decrease in size of the jaws and teeth through savage and primitive races to those of the highest civilised type, and there seems good reason to believe, although it has not been demonstrated, that the teeth are of relatively inferior structure; but in this respect the dental development of the different civilised peoples seems to vary considerably.*

* The late Professor Flower (Curator of the Royal College of Surgeons and British Museum), after examination and measurement of many thousands of skulls, constructed a dental index, and in this the average size of the teeth of the gorilla being represented by 50·8, the Tasmanian by 47·5, and other savage races holding intermediate positions, the European stands at 40·5.

It is only within recent years that any systematic attempt has been made to enquire into the condition of the teeth in masses of the population. Examination of the teeth of school children has latterly been carried out sufficiently widely to prove the almost universal existence of caries, and, therefore, it is to be inferred, of ill-made dental tissues. But it is impossible to prove whether inferior structure and resulting decay are more common now than in former generations.

Ill-made dental tissues are often hereditary, and structural characteristics may often follow those of one parent only. Nothing is more common than to find, in members of the same family, teeth of one general type and quality, or teeth presenting in exactly the same situations, flaws or patches of inferior formation. The current knowledge of the causation of the varieties of defective structure, gross and microscopical, now grouped under the heading "Dental Hypoplasia"—the effects upon the teeth of hereditary syphilis, and also of stomatitis, and other morbid influences, acting during the progress of calcification—have been discussed in an earlier chapter; and although the typical teeth of Hutchinson—the significance of which are unquestionable—are present in only a small proportion of undoubtedly syphilitic children, their occasional occurrence clearly shows the power of hereditary disease to influence the histological development of the teeth.

An intimate connection between dental mal-development and any other diathesis, besides the syphilitic, cannot be fully demonstrated, yet there are some of these constitutional conditions with which badly made teeth seem more or less associated. It will, probably, be agreed by most observers that imperfect dental tissues are present in a great number of patients of the type usually classed as "scrofulous." With rickets inherently

defective teeth will also generally be found. Phthisis is now known by no means to indicate invariably the tuberculous diathesis, and keeping distinctions in view, it may be said generally that ill-made teeth are not at all a constant accompaniment of any form of phthisis, nor are they especially noticeable in a majority of patients of undoubtedly tubercular tendency. Faulty dental tissue development cannot be associated generally either with the rheumatic or gouty constitution. Indeed, with the latter, both teeth and jaws are often of unusually massive and solid character.

In view of our limited knowledge of the causation of degeneracy of enamel and dentine, what general measures can be suggested likely to lead to improvement in the quality of the tissues, and to aid in the prevention of dental caries? Such a general question can be answered only in general form. Whatever tends to improve the physical development of a race should cause a relative improvement in the structural qualities of the teeth. In this connection the facts given in an earlier page with regard to the much greater frequency of dental hypoplasia among the children of the poor than among the well-to-do are highly significant, and will fall here into place without further emphasis.

It may next be asked can we, by treatment, influence beneficially the developing teeth of the fœtus in utero, through a mother? The answer must be that little reliance can be placed upon treatment specifically directed to this end, and we must depend mainly upon measures for the amelioration of the mother's general health, and the eradication of any definite morbid constitutional taint. The treatment of these conditions is quite beyond the province of the dentist, although it is the duty of the dental physiologist and pathologist to explain the laws which should govern treatment directed

to the developing teeth. To show that defective teeth might occasionally result from deficient supply of the necessary pabulum through the mother, several cogent facts have been brought forward. It has been pointed out that in a pregnant woman the union of a fracture is slow, the inference being that the lime salts are all required for the formation of the bones of the fœtus; and this is borne out by the fact that osteophytes and bony thickenings sometimes present in the early months of gestation become absorbed as pregnancy advances and bone begins to form in the fœtus. In presence of these facts, a rule may be established that in every case of dyscrasia or cachexia during pregnancy, and particularly where there is a tendency to atrophy and bony wasting, there should be administered mineral nutrition, both through the medium of a suitable dietary and of the preparations of lime salts to be found in the pharmacopœia.

In previous pages the reasons have been given for the opinion that enamel once fully calcified is physiologically unalterable, and it follows that after the formation of enamel any attempt to prevent caries by improving the quality of that tissue must be futile. The exteriors of the crowns of all the temporary teeth—from caries of which children suffer so much—are fully formed at birth; these teeth can therefore be influenced only through the mother. By this time, the first permanent molars and the permanent incisors and canines are so far advanced in development, that it is open to doubt whether treatment can have any effect upon their enamel.

It is difficult to believe that any treatment could influence cases in which a strong hereditary influence proceeding from the father gives a bias to dental development. A mother with good dental tissues will

often bear children whose teeth will prove defective, having the closest resemblance in form and structure to those of the father, who may be perfectly healthy, and in whom this may be the sole physical defect.

When the child is born, syphilis and specific diseases will receive their appropriate treatment, whilst the well-known rules of hygiene are enforced for the improvement of the general health. We are, to a great extent, ignorant of the actual causation of defective dental tissues. It cannot be always due to lack of lime salts, or the whole skeleton would in every case be equally defective with the teeth. But as uncertainty exists, it may be better to err on the right side—especially as the error would be harmless—and enforce the rule that in every case in which ill-made tooth tissues are likely to appear, an attempt by diet and therapeutics should be made to supply to the developing tissues the mineral constituents of which they may stand in need. This rule should, of course, especially be enforced in those diseases, such as rickets, in which the whole skeleton is ill-constructed. There is no difficulty in administering lime to an infant from birth. A child should have no food except its mother's milk, if this is of proper quality, up to at least the sixth month. Practically, in the majority of cases, this source is supplemented by cow's milk; which, of course, with well-managed children, is diluted and prepared in the usual way to resemble human milk. It happens that lime water (liquor calcis) is found to be an admirable aid to the digestion of milk in infancy, and this can either be added to the supplementary food, or can be given separately.

It is impossible, particularly when both causes are present, to determine in any case the exact share which inherently weak enamel and vitiation of the secretions

severally take in causation of caries, and when discussing the association of ill-made dental tissues with certain diatheses, it must therefore not be forgotten that some of these diatheses have as a common constant accompaniment vitiation of the secretions of the mouth. Thus one type of "scrofulous" subject—that with coarse features, muddy complexion, and long thick upper lip—has usually a chronic condition of congested buccal mucous membrane with secretion of viscid mucus. Again, rickets is often preceded and attended by a virulent form of acid dyspepsia.

In a similar way, the prevalence of caries is to be accounted for among certain individuals or portions of the community, whose physique and general health in other repects are not to a corresponding degree inferior, and whose dental tissues are not evidently of the worst structure. For example, the constant presence of dyspeptic troubles in some classes of factory operatives is enough to account for the rapid tooth decay from which they suffer. Dyspepsia due to sedentary habits and improper dietary—superabundance of coarse food and alcohol—is so common in some of these communities that it is regarded as a matter of course, and endured as one of those evils from which their is no escape.

The broad facts must be kept in view, that without acid — without the factors which render possible the occurrence of acetous fermentation in matters lodged about and upon the teeth—caries cannot be started; and that acid capable of dissolving enamel—and of more rapidly dissolving enamel in proportion as the tissue is soft and ill-made—is always being formed in greater or less quantity in every mouth in which perfect cleanliness does not uniformly exist.

In combating this cause of caries, the patient's general health must first be considered. Probably

every lapse from a perfect standard will be accompanied by a proportionate vitiation of the secretions of the mouth. The question of general health is, however, for the physician, not the dentist. But even with perfect health and perfect dental tissues, caries may appear if organic *débris* be allowed to remain and decompose in contact with the teeth. The first thing, therefore, in the prevention of caries is to ensure mechanical cleanliness by the use of tooth-brush and tooth-pick. A tooth-pick properly employed is important. The use of those of quill only should be allowed; wood is apt to break and leave minute splinters between the teeth; metal may scratch and fracture the enamel. The tooth-pick should be used at night to clear away remains of food from between the teeth, before they receive their final brushing. It is important, especially with children, to insist upon the necessity for thorough cleansing at bed time; otherwise, the teeth may be left habitually coated with food *débris,* during at least eight out of twenty-four hours. Where the teeth are crowded and are of delicate structure, the use of fine silk thread passed between the teeth and rubbed to and fro supersedes the tooth-pick; and with children this is always the best method.

A dentifrice ought always to be compounded of alkaline bland and soluble materials, and ought never to contain substances like levigated pumice, which are often added to whiten the teeth, and do this by slowly grinding away the surface of the enamel. A simple inexpensive tooth powder, calculated to do all that such a preparation can do to remove *débris* of food and to neutralise acid secretions, may be composed of soap powder and precipitated chalk—about a drachm of soap to the ounce. To this may be added a few drops of carbolic acid or oil of cloves and of oil of eucalyptus; and where more efficient antisepsis is called for the

quantity of these may be increased. Care should be taken that the soap powder is fresh and of the best quality, or a disagreeable flavour may be produced. A more pleasant and efficacious mixture would be represented by the following:—powdered soap one to three drachms, boric acid two drachms, powdered orris root one drachm, precipitated chalk one ounce. With fastidious patients, it is well to add perfumes which they prefer. Attar of roses, and oils of lavender, cloves, geranium and eucalyptus, afford a choice, and with one or several of these used together, it is possible to impart a delicate perfume to the powder and make it highly agreeable—an important matter with preparations intended for habitual use in the mouth. A dentifrice ought, of course, to be thoroughly triturated and reduced to impalpable powder.

In fevers and other diseases in which the patient is either too feeble or too listless to clean his teeth for himself, this should be done by an attendant. In such cases, and in all those where great vitiation of the secretions is present, as in the zymotic fevers and the dyscrasia of pregnancy, extra means should be adopted to prevent putrefaction and fermentation in the deposits which form upon the teeth. Thorough cleansing of the teeth in this way will often suffice to prevent toothache, which in certain conditions—particularly during pregnancy—is sometimes clearly due to irritation of carious cavities by the products of decomposition.

Perchloride of mercury is by far the most potent drug for this purpose, and may be used in severe cases. A solution of a strength of 1 in 5,000 is antiseptically equivalent to a 2 per cent. carbolic acid solution, which latter, although not more powerful than needed to prevent fermentation, is too strong to be used as a mouth-wash. A not unpleasant mixture of perchloride

can be made if one grain be dissolved in an ounce of eau-de-Cologne or tincture of lemons. Of this, a teaspoonful is to be mixed with a wine glassful of water, and the mouth after thorough brushing of the teeth to be rinsed with it several times a day. The mixture approximates a strength of 1 in 5,000. Some patients complain of a lasting disagreeable metallic taste, following use of the perchloride wash. To overcome this, and also to guard against the swallowing of even a minute quantity of this very poisonous drug, the mouth may be well rinsed with warm water, or warm water to which has been added a little spirit of wine, lavender water, or eau-de-Cologne.

The cleansing of the teeth during convalescence from exhausting diseases is too often forgotten by attendants. If the foul state of the mouth be relieved, it will frequently be found that the desire for food will be at once increased, particularly in fastidious subjects. Patients seldom think of asking for this relief when too feeble to use a tooth-brush for themselves.

Mouth-washes for ordinary use may be prepared with any of the antiseptics in common use—carbolic acid, chloride of zinc, or permanganate of potash. Pleasant and efficacious lotions may be composed of boric acid and tincture of myrrh, with lavender water and eau-de-Cologne, or tincture of lemons. Preparations containing thymol, menthol, oil of winter green, and other similar antiseptics, have of late been brought into use. All lotions are much more likely to fulfil the desired end when used with a tooth-brush, friction being necessary to cleanse the teeth from shreds of food and adherent mucus. For this reason a powder, when it can be used, is to be preferred to a lotion, and in every case the importance of systematic sweeping and cleansing of the teeth and interstices by means of a thin

flexible quill tooth-pick or silk thread cannot be too strongly insisted upon.

The third main pre-disposing cause of caries—crowding and irregularity of the teeth—has been discussed in previous chapters. The measures which may be taken in prevention and cure of these conditions have been described; and the danger of setting up decay by prolonged or careless use of regulating instruments having been sufficiently dwelt upon, calls for no further reference here.

TREATMENT OF CARIES. THE OPERATIONS OF EXCISION, OF STOPPING, AND OF INLAYING WITH PORCELAIN.

Excision.—The treatment of incipient caries may be confined in some instances to cutting away the diseased tissues, polishing the surface, and leaving it of such a form that it may be readily cleansed, and may not allow the adhesion of decomposing particles of food. This procedure is in imitation of the process of spontaneous arrest, sometimes effected fortuitously during the progress of the disease, which was described on an earlier page.

The treatment of caries by the simple operation of excision, is applicable only in rare cases to the grinding surfaces of the teeth, but is commonly resorted to with success in dealing with decay of contiguous surfaces, especially those of the incisors and canines. The cases most fitted for this treatment are those in which the teeth, although they may be crowded, are not irregular. The operation is performed under the most favourable circumstances when the enamel alone is superficially affected. Carefully performed, the operation is then often of life-long efficacy. It may be occasionally carried out with permanent advantage even when the dentine has been penetrated to some slight depth. As a rule, it should not be undertaken in mouths where chronic inflammation and sponginess of the

gums prevail; neither should it be proposed in any case when the carious surface extends below the gum. At the level of the gum it is desirable in most cases that a portion of sound tissue should remain projecting from each tooth, so as to prevent the cut surfaces from again gradually falling into close apposition, which they are apt to do in crowded jaws. The angle where the cut surfaces spread apart near the neck should be obtuse, so as not readily to hold foreign particles. The surfaces should be left perfectly plane, and with such an inclination that the space between teeth is V-shaped, the wider part so directed as to be easily accessible to the tooth-brush and to the tongue, and subject to the constant beneficial friction of mastication. In forming surfaces in this manner it is sometimes necessary to cut away a considerable quantity of sound tissue. Judgment and discrimination must be exercised in this procedure; in most cases where the decay is more than superficial, and approaches the dentine, it will be found best to separate the teeth somewhat by the file and fill the small cavities still remaining. If dentine is exposed during the operation, the portion of the surface towards which decay has advanced, must not be left unless with perfect assurance that it has not been affected in the least degree by acid solution, or any carious action; otherwise decay is certain to continue. Careful preliminary examination will usually reveal the fact when dentine is affected; and it will be possible to determine beforehand in most cases when stopping will be necessary after partial chamfering. The amount of tissue which may be safely removed varies with the size of the tooth, but it must be borne in mind throughout, that if too much be removed the tooth may be left unbearably sensitive, owing to near exposure of the pulp. In the case of incisors and canines the excision

of tissue may be confined always to a great extent, and sometimes entirely, to lingual surfaces, the teeth being thus preserved from perceptible disfigurement.

The instruments required in the operation consist of enamel-chisels and files; with the chisels—when applied in the direction of the enamel fibres—the decayed tissue may be rapidly and painlessly broken down; with files of different degrees of coarseness the operation may be continued, and the surface made ready for the final polishing.* This latter process is accomplished by

FIG. 138.

rubbing the surfaces first with finely-powdered pumice, carried on wet tape or on a strip of cane, to remove the file-marks, and afterwards with a strip of wet slate-stone, to make it perfectly smooth. The whole process of cutting and polishing is, of course, much more perfectly and easily performed with the dental engine, and the wheels, burs, and discs with which it is provided. Fig. 138 (from Arthur), indicates the most favourable form in which the interstices of the teeth can be left

* With regard to instruments employed throughout the operations of dentistry, it may be well here to remark once for all, that besides those of common form and design used by the majority of practitioners, many varieties of every class of instrument are now to be had to meet the requirements of exceptional cases or to satisfy the fancy of individual operators. Fully to illustrate all these appliances would take up many pages; and this seems unnecessary, seeing that they are figured and described in the catalogues of all the principal manufacturers.

after this treatment. The sensibility of exposed dentine, varying in amount in different cases, which often remains for a time after the operation, may be rapidly diminished by application of zinc chloride, and the use of a lotion containing spirit.

One or two thorough applications of zinc chloride usually suffice to permanently deaden the surface. A small portion of solid chloride in powder, carried on a strip of wood or cane, may be rubbed over the moistened surface. A spirit lotion — rectified spirit or eau-de-Cologne answers well—may be used to moisten a length of tape, with which, slipped between the teeth, the surfaces may get a daily rubbing.

The operation of Stopping or Filling. — When, owing to its extent or to other circumstances, caries cannot be dealt with by the method just described, it must be treated by the operation of stopping or filling the tooth. This operation, which forms a special complex branch of surgical handicraft, cannot be entirely learnt from books. Books can only supply instruction in general principles, with explanation of methods and description of means of operating. Book knowledge must be supplemented by tuition at the chair side, such as is provided at dental schools. Upon this part of his education the student enters prepared by previous training in mechanical dentistry; and by this time—unless he is devoid of natural aptitude and has mistaken his vocation—his fingers will be so trained that the simpler operations of dentistry, when understood, must appear easy to him.

Knowledge having been obtained of the principles upon which operative procedures are carried out, and of the materials and instruments employed, the student cannot commence too soon to acquire skill by practice and experiment. This practice is easily obtained by the

dental student. He may begin by plugging with tinfoil cavities cut in bone or ivory or in extracted teeth, each stopping after completion being carefully broken up to discover in what detail it has failed, or in what direction it is capable of improvement. In the same way, other operations, to be described in later pages, such as capping the pulp, extirpation of the pulp and fang-filling may also be practised. For this purpose, extracted carious teeth are best preserved in spirit, which prevents the pulp from drying and shrivelling. As soon as the student can with rapidity and certainty fill difficult cavities in extracted teeth fixed in a vice, he may safely proceed to operate upon simple cavities in the mouth of the living subject.*

The process of stopping is an old, perhaps an ancient operation, but it has not been widely practised until within comparatively recent times—and only within the last thirty years has it been advanced to a position among the most uniformly successful of surgical procedures. Beautiful work, especially in filling with soft gold foil, was executed by a recent past generation of dentists; and those practitioners of the present day whose professional career began twenty-five years ago, can testify to the numbers of gold stoppings met with at that period, which had been inserted into the teeth of youthful patients, and had endured until advanced age. The older practitioners were hampered by the necessity of excavating and shaping cavities by hand power alone; whilst in permanent filling materials they were

* A great number of teeth in every stage of decay are extracted in hospital practice, many, only slightly affected, being removed from young patients in the treatment of crowding and irregularity. If these teeth are preserved as suggested, they afford students the means not only of practising operations on every form of cavity, but of examining and making themselves familiar with the internal anatomy of the teeth, with the form and size of the pulp chambers, and of the nerve canals of the roots.

virtually restricted to soft gold foil and a few amalgams, most of which could not be always relied upon.

Then again, not only was the pathology of the pulp imperfectly understood, but antiseptic processes had not been thought of; and few practitioners made any attempt to save a tooth permanently even when a living healthy pulp was exposed, much less when the pulp was diseased or dead, and the chamber and canals filled with putrid *débris*, and least of all, when alveolar abscess was present. The dental engine was invented some thirty years ago, and since then the machine itself, as well as the tools it actuates, has been steadily improved. This invention has put an end to the wearing fatigue of the operator, and has lessened the suffering of the patient to a vast extent. The dentists operating chair is also practically a recent invention.

Then again, filling materials have been made comparatively perfect, albeit an ideal stopping—plastic, adhesive to the walls of the cavity, non-conducting to heat and indestructible—remains yet to be invented.

The preparation of gold for filling has been enormously improved, not only in the production of the material in form of mass and foils, with high cohesive property facilitating the building up of fillings, but also in manufacture of cylinders, pellets, and other forms of non-cohesive foil of exquisite plasticity.

Thanks more particularly to the labours of Mr. C. Tomes and Dr. Black, our knowledge of the physics of amalgam fillings has at length been placed upon a scientific basis; and acting upon the data now available manufacturers are able to supply materials in every way more to be relied upon than earlier products.

Non-metallic cements also are a comparatively recent invention, and these are invaluable as temporary stoppings, and as linings for deep cavities.

The process of porcelain inlaying—the last improvement of all—has only within the last five years been advanced to its present degree of perfection and of wide applicability.

In the invention of apparatus for preventing access of saliva to cavities under operation, great advance also has been made. Napkin-holders and clamps, and above all the "rubber dam," with the automatic saliva ejector, have rendered it possible to undertake, with the assurance of success, procedures in which the danger of failure under former conditions could never be entirely averted.

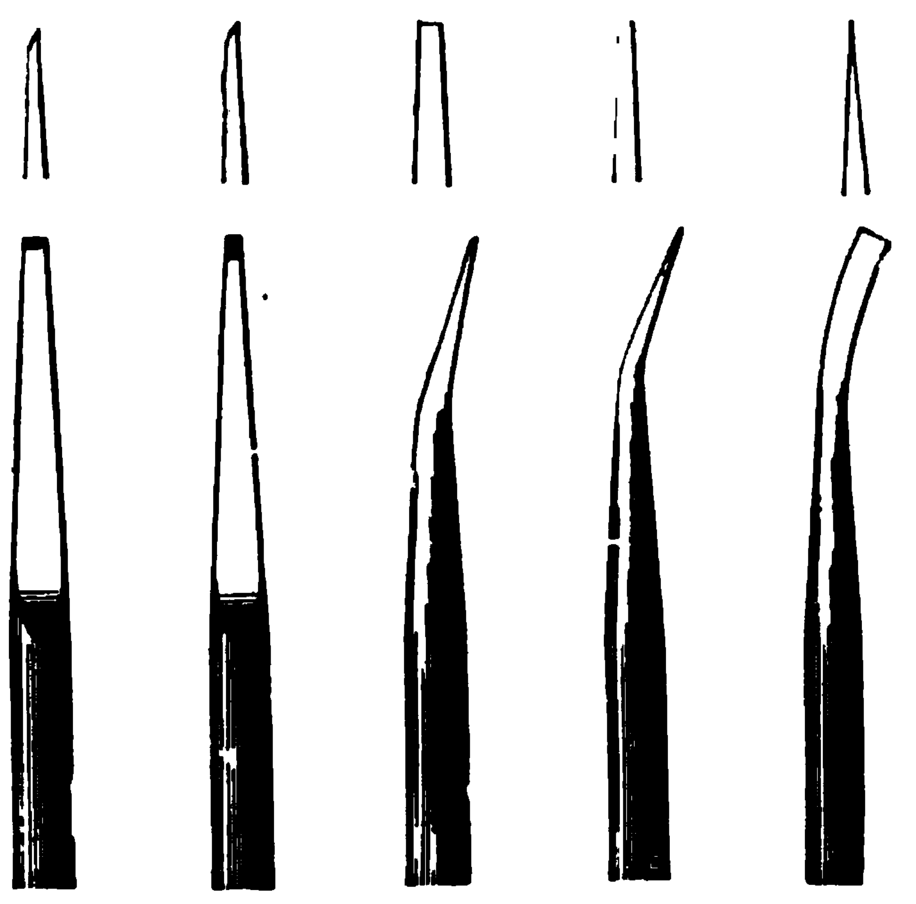
All these subjects have now to be elaborated; and it will, in due course, also be explained how antiseptic methods render it easy to save many teeth, the diseased conditions of which were formerly looked upon as beyond treatment, so that conservative dentistry has been placed, in this regard, on a level with the general practice of advanced antiseptic surgery.

The operation of stopping, as suggested in the preceding paragraphs, comprises cutting out the diseased tissues and forming the cavity for retention of a filling, drying the cavity, and filling it with some suitable material. It also includes pressing teeth apart in order to gain access to cavities in interstitial positions. The operation is conducted always on the same principles, but its details vary considerably according to the position, character, and extent of decay. The present chapter will be restricted to the treatment of cases in which the central chamber of the tooth has not yet been laid open by caries, and in which the dental pulp is free from disease.*

* To facilitate description more or less arbitrary division of the subject is necessary; but no student will attempt operations without thorough knowledge of the pathology, symptoms and diagnosis of the inflammatory sequels of caries.

The operation of filling, throughout all its details, is much facilitated by the use of a dentist's chair, which allows the patient to be firmly and comfortably placed in the most suitable position, raised when a tooth of the upper jaw, and lowered when a tooth of the under jaw, is to be filled, with the head tilted forwards or backwards, the face turned towards or from the operator, according to the position of the tooth and of the cavity of decay.

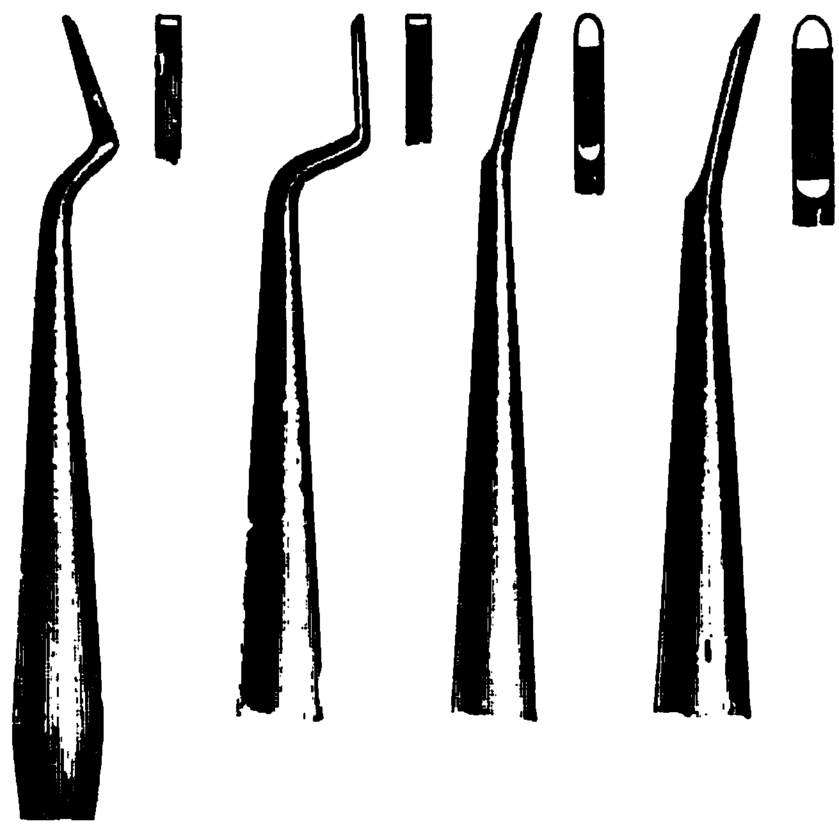
FIG. 139.



The instruments used in excising carious tissues consist of enamel-chisels, drills and excavators. The chisels are sufficiently described by their name, both as regards their nature and use. They are made with blades of different sizes, bent at various angles, so as to reach the decay wherever situated. A set sufficient for ordinary use is shown in figs. 139 and 140. With them the carious enamel of the walls of cavities can be speedily

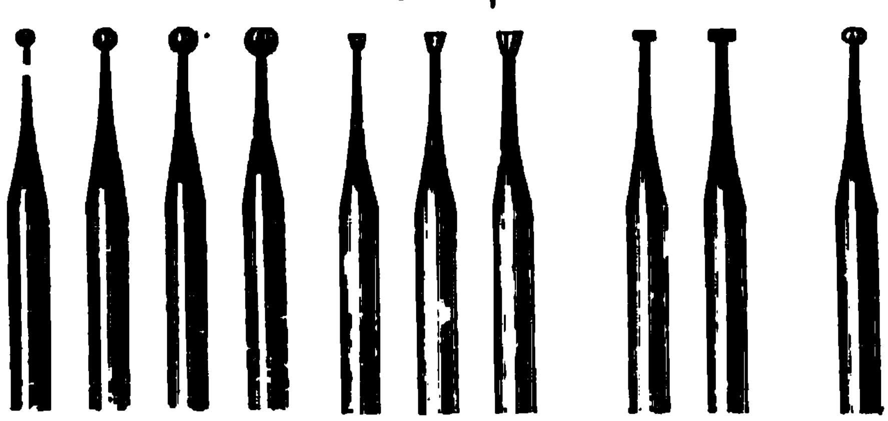
broken down with but little pain to the patient. The chisel should be held firmly with the handle in the palm of the hand, the thumb being lodged securely against

FIG. 140.



the tooth to control the instrument and to prevent it from slipping. It should be applied in the direction in which the enamel fibres run.

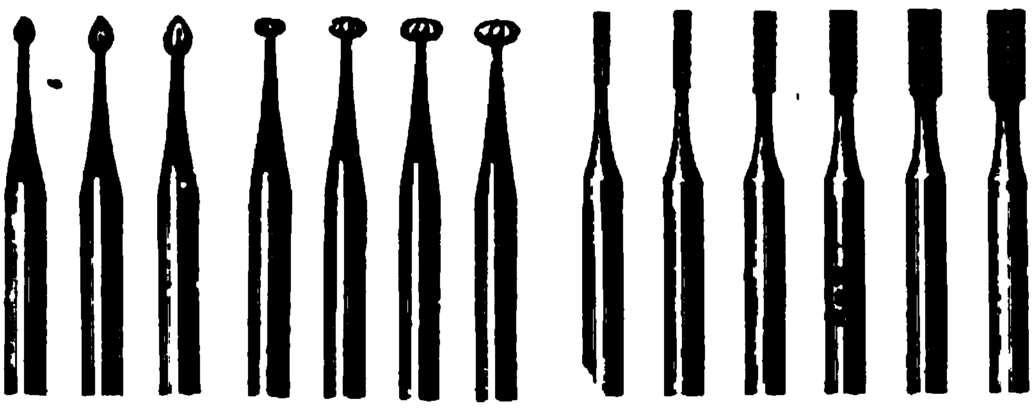
FIG. 141.



Dental drills are mostly of two kinds, the rose or burhead, and the sharp-bladed drill. The cutting point of the rose head forms a circular or conical file. It is

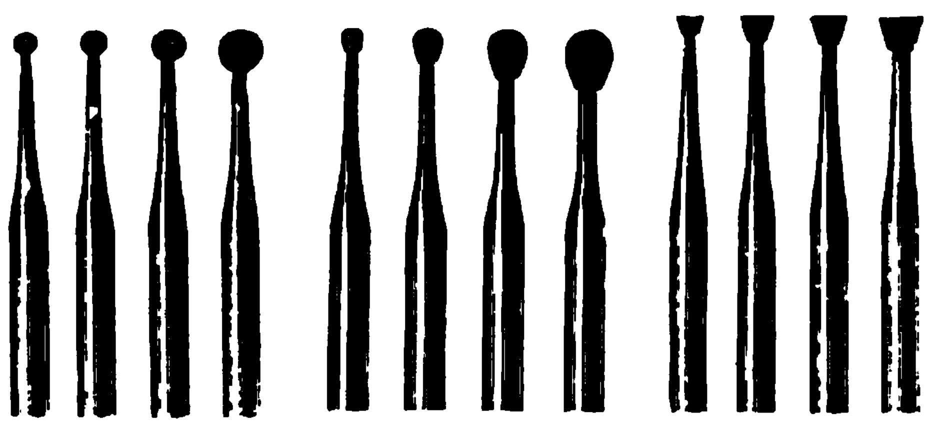
used to open up the ragged orifices of cavities and to grind away the carious tissues within. Sharp drills serve to cut through the crown in gaining access to cavities, to open up small cavities and fissures in the enamel, to shape the cavity, and to cut retaining points

FIG. 142.



into which the filling is to be dovetailed. The general character of these drills is sufficiently exemplified in the selection depicted in figs. 141, 142, 143, 144, 145 and 146. These drills and many other useful varieties of cutting, filing and polishing instruments, are now usually employed

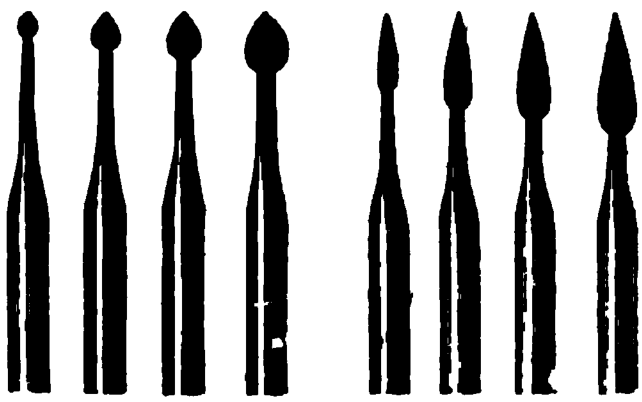
FIG. 143.



in conjunction with the dental engine. This machine consists of a flexible shaft rotated by a band, which is driven by a treadle and fly-wheel. The extremity of the shaft which carries burs, grinding-wheels, drills and discs and cones of any desirable size and shape, revolves with

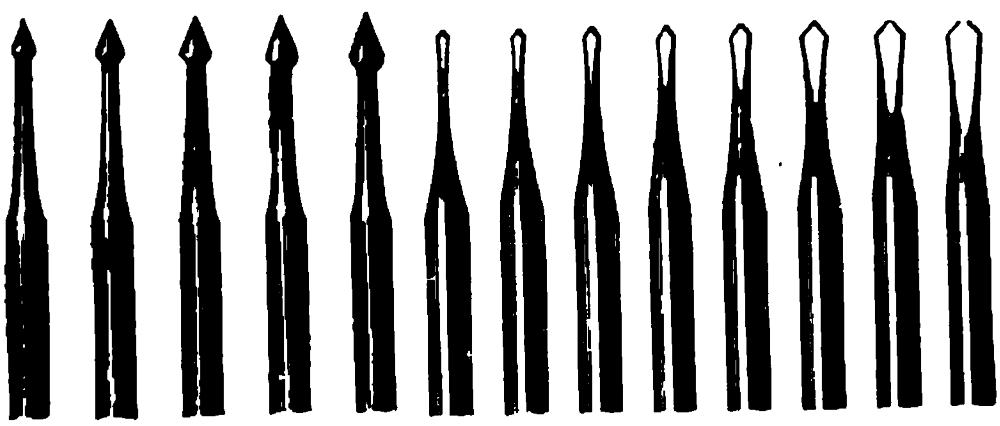
great rapidity, and enables the operator to excise tissue with great facility, and speedily to reduce to smoothness the ragged or rough margins; and afterwards to polish all surfaces with exquisite nicety.

FIG. 144.



Wheels, discs and cones are illustrated in figs. 147, 148, 149, 150, 151 and 152. All these shapes and patterns, and many others, are made in a variety of materials. For grinding they are made of corundum of different degrees of coarseness; some having rapid cutting power, others, of finer texture fitted to reduce

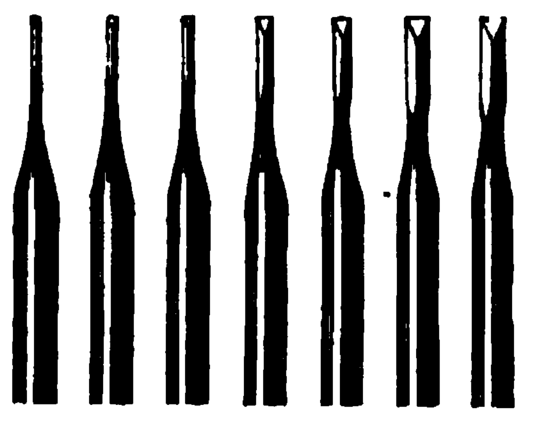
FIG. 145.



rough surfaces to smoothness preparatory to polishing For polishing purposes they are made of wood and of vulcanised india-rubber, and are used with levigated pumice, and with chalk or whitening. Others made of

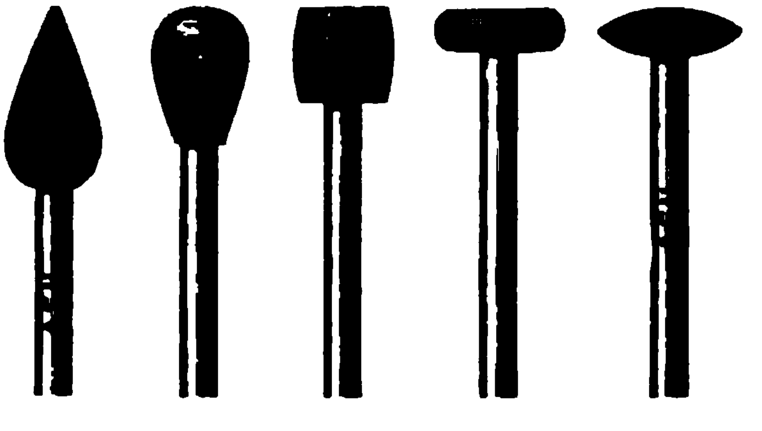
Arkansas stone produce a surface ready for burnishing. Again, mandrils are provided which carry small discs of emery and sand paper admirably adapted for polishing sóme surfaces, especially in narrow interspaces.

FIG. 146.



Excavators serve to pare away dentine. They are made of all sizes, some with flat blades, some hoe-shaped, some spoon-shaped, and others sharp-pointed ; and they are curved and bent at various angles to reach the differently situated cavities, and some to cut with a pushing, others with a drawing movement. Useful forms of excavators are shown in fig. 153, 154, 155 and 156.

FIG. 147.



With regard to the performance of the preliminary step in the operation of filling, at present under discussion, it may be laid down in the first place as a rule, subject to important exceptions to be mentioned further

on, that the whole of the carious tissues should be removed. If the orifice of the cavity and a sufficient depth of outer wall be not formed of sound tissue, decay will proceed unchecked after the insertion of the filling. The beginner is most liable to err, by

FIG. 148.

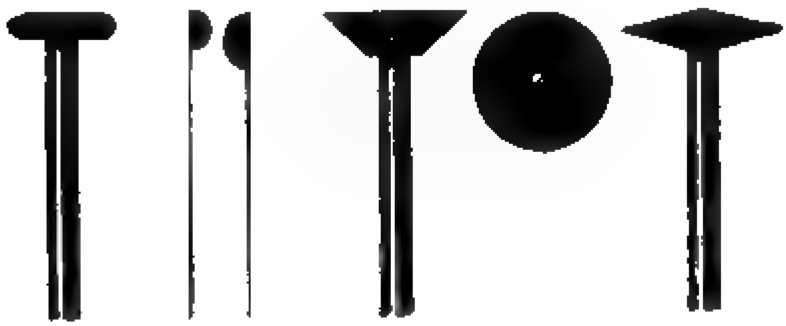
too limited use of the chisel and excavator at the orifice, too free use in the depths of a cavity. It will be perceived at once that carious cavities are in form rarely either regular or symmetrical. Most often they assume an irregular star-shape, with numerous horizontal branches or carious channels running in

FIG. 149.

different directions from the main cavity. If only one such shaft communicating with the exterior or covered with a thin shell of enamel be left, the durability of a stopping must of course be much curtailed. The danger of overlooking and leaving unsound enamel is greatest at

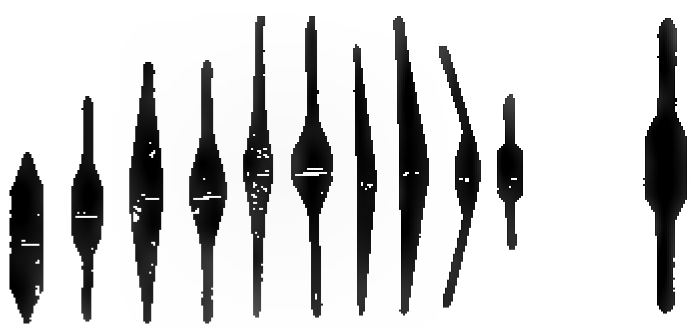
the margin of the free edge of the gum—the cervical edge—and more especially in cavities on the mesial or distal surfaces. In these positions, although the difficulty of examining the seat of decay is great, the operator must satisfy himself that no unsound enamel remains.

Fig. 150.



It is between the teeth and beneath the free edge of the gum that decay after filling is most apt to recur, for it is there that in spite of a patient's care foreign particles tend most to lodge and decompose; and there that incipient caries if present is certain to progress. The more the

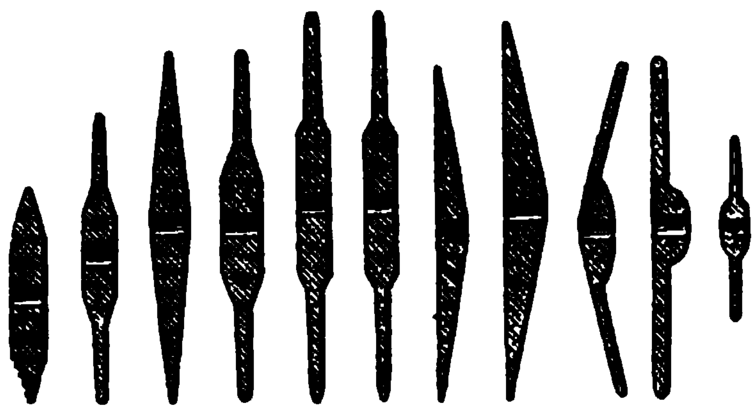
Fig. 151.



tissue towards the neck of a tooth is excised the more difficult it becomes, at this particular part of the cavity, to form a solid foundation for a stopping, hence the young operator may be tempted to leave enamel about the condition of which he may feel doubtful. To cut

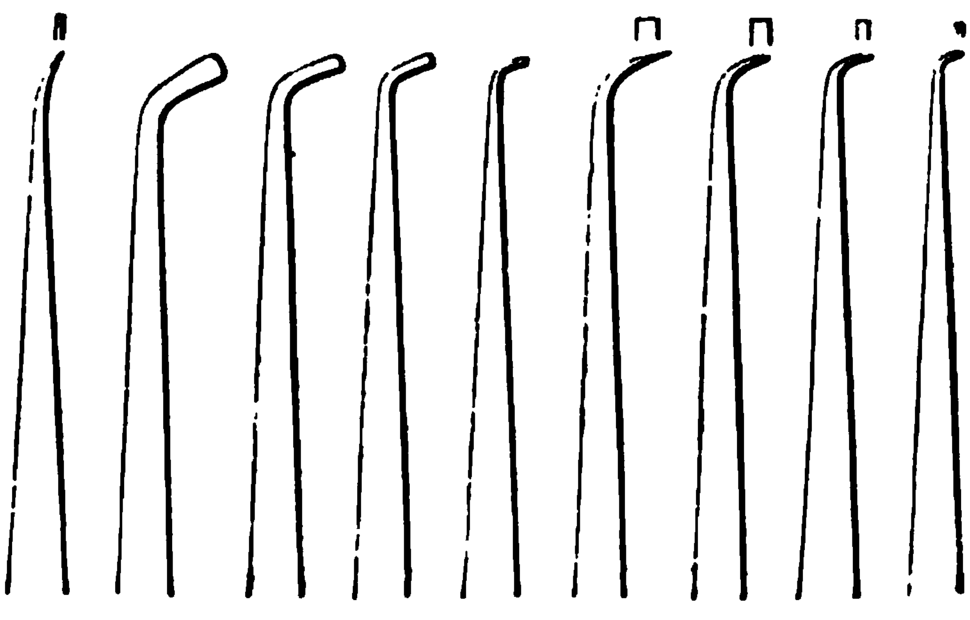
away solid tissue without sufficient reason is unjustifiable; but to carry the excavation as far as the margin of the cement is better than to leave exposed a layer of partly decalcified enamel, certain to speedily break down.

FIG. 152.



It very often happens that dentine beneath disorganised tissue appears stained to a brown or darker shade, whilst showing neither appreciable softening nor other physical change. It is seldom necessary to cut away

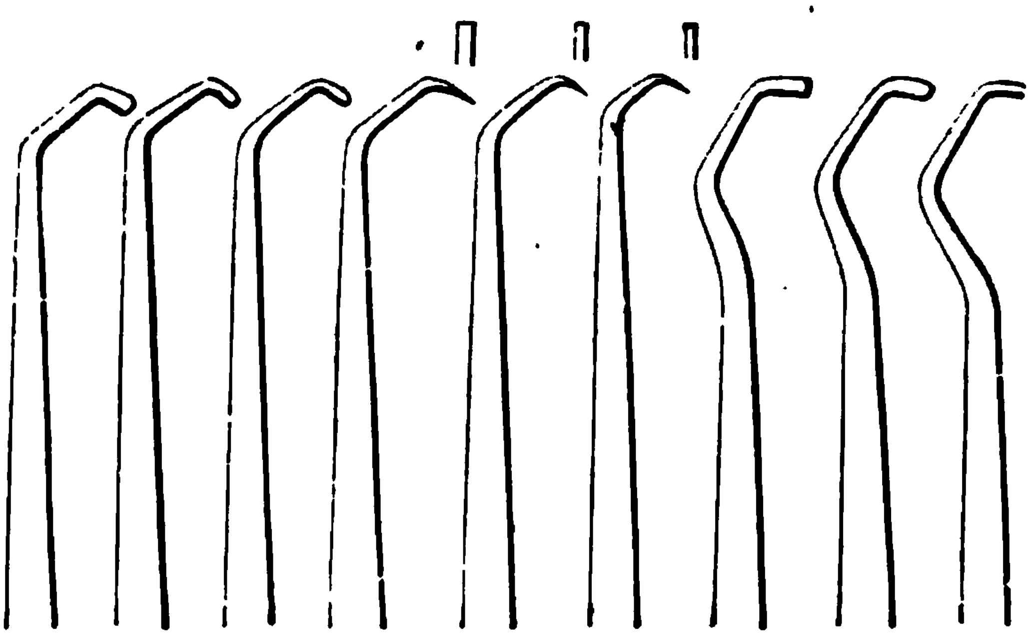
FIG. 153.



tissue in this state; but whilst it must not be forgotten that the nearer the pulp is approached by a filling the greater becomes the risk of loss of a tooth, it must be also borne in mind that very nice discrimination is

needed in leaving carious dentine in close proximity to the pulp. It has been explained in previous pages, that microscopic examination of dentine for some distance below the area of marked softening, shows small numbers of micro-organisms which have penetrated the tubes in advance of the main body, and in situations where no decay is perceptible to the naked eye. A layer of dentine in this condition comparatively distant from the pulp-chamber, may after thorough sterilisation be left with safety beneath an hermetical filling. But a pulp covered only by a thin layer of affected tissue must

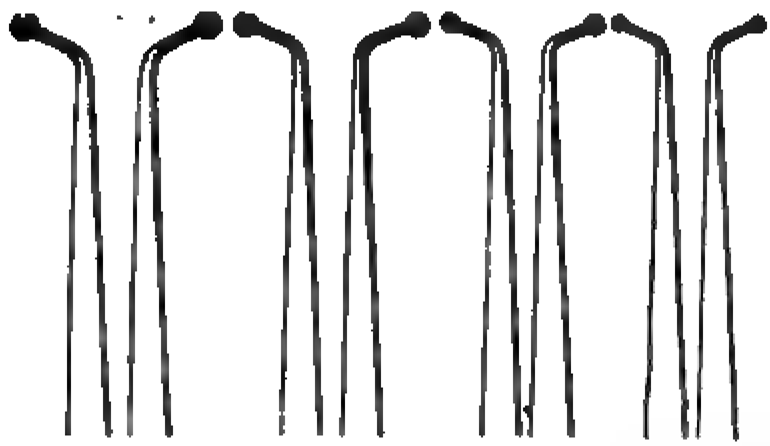
FIG. 154.



be looked upon as virtually exposed; being accessible to micro-organisms and septic matter. In cases where there is a history of inflammation of the pulp characterised by occasional attacks of throbbing pain, diagnosis is easy; but this symptom is often absent. Before inserting a permanent filling the operator must strive to satisfy himself, not only by negative evidence—absence of symptoms of pulp irritation and inflammation—but also by careful exploration that the pulp is in no sense exposed, and that it is covered by a layer of dentine in which caries is not and has not been active.

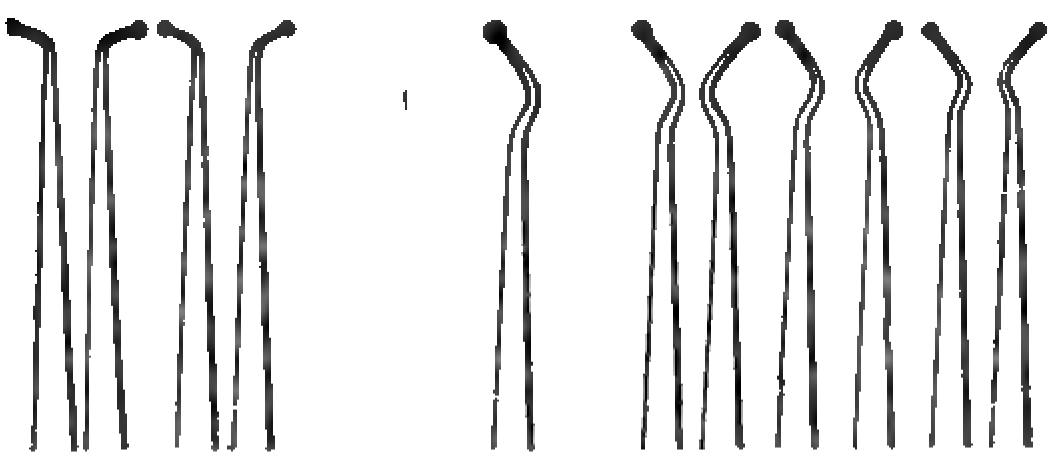
In cases in which the pulp cavity is closely approached by decay and when the pulp is believed to be free from disease the greatest care must be exercised to avoid

FIG. 155.



laying open the chamber, for if this accident happen the chances of saving the pulp are much diminished. When danger of the accident exists, the softened dentine from the depths of the cavity must be slowly and

FIG. 156.



cautiously removed, and for this purpose excavators with spoon-shaped blades should be used, to avoid the danger of a sharp point plunging through the softened tissues,

and through a thin layer of sound dentine into the pulp chamber. If it be found that excision of all the affected dentine cannot be accomplished without risk, a general rule may be laid down, subject to the cautions and reservations dwelt upon in previous paragraphs, that it is better to leave a layer of slightly affected tissue in the depths of the cavity. Dentine in the earliest stages of carious attack may be always left with safety in the deeper parts of cavities, for it can be brought into such a condition, and placed under such circumstances, as will prevent it from decaying further. Caries cannot go on without the influence of external agents, and all that is wanted in the case in question is to harden the slightly affected dentine by abstracting completely its extrinsic moisture, to render it perfectly aseptic, and to protect it by a filling from the action of external agents. Partially disorganised dentine may be treated by filling the cavity with a plug of gutta-percha or of cotton wool, saturated with a solution of gutta-percha in chloroform, or gum mastic in spirits of wine, with a dressing beneath and the whole being renewed at intervals of a few days over as long a period as necessary. The dressing may be composed of a pellet of absorbent cotton wool moistened with carbolic acid, oil of cloves, or solution of perchloride of mercury, one in two thousand. In the majority of cases the drying of the tissue by application of absolute alcohol, aided by the hot-air syringe, will suffice.

Methods of excluding saliva and drying cavities are more particularly discussed in later pages, but the use of absolute alcohol, with the hot-air syringe, a method of sterilisation, as well as desiccation, employed in treating cavities in several later phases of decay, besides the one under immediate consideration, may be now, perhaps, most fitly described.

Absolute alcohol was first introduced as an agent in dental practice by Mr. Henry Sewill, in the year 1874, in a communication to the Odontological Society.* The use of the fluid was suggested by its employment in microscopy for the drying of sections. Absolute alcohol has a strong affinity for water, combines with it, and if exposed to the air carries it off by evaporation. It was proved by experiments on extracted teeth that alcohol has the power, not only of desiccating the softened flakes of carious dentine lining a cavity, but also of abstracting to some depth the moisture intrinsically held by healthy tissue. Such dehydration of a surface in a tooth, with living pulp and periosteum, would no doubt be of short duration; the dried tissue would again slowly take up moisture from within; but the temporary condition would be of importance in treatment.

The year 1874 was before the era of antisepticism, and at first the alcohol was employed merely as a drying agent. Later—as explained in the second and third editions of this book—it was used in conjunction with other agents for the purpose of sterilisation, as well as desiccation.

Absolute alcohol alone is, however, a powerful germicide, and there is, probably, no species of organism which would survive treatment with this agent. When to this fluid is added another potent antiseptic, its efficacy is made doubly sure. Perchloride of mercury may be thus added. The quantity of this poisonous drug—probably the most potent of germicides—used in applications to carious cavities is too small to be injurious; and, moreover, as it cannot pass into the system through dentine, and not a trace need be

* Trans. Odont. Soc., Vol. VII., New Series, 1874.

swallowed during its use, it can be used of a strength which would be prohibited in dealing with a wound of vascular tissues. A mixture of one part to two thousand of absolute alcohol, forming a germicidal mixture of more than necessary potency, may be used in preparing dental cavities. From a fraction of a drop to a drop or two only is used in each application. This is taken up on a pellet of absorbent wool, and, saliva being excluded, the cavity, previously dried with cotton wool, can be swabbed with the fluid.* After a pause of a few moments to allow the spirit to combine with the water of the surface, the hot-air syringe may be brought into play; and when evaporation is completed the swabbing may be repeated; and this procedure may be carried out again and again, if it be deemed desirable.

The hot-air syringe consists of the usual india-rubber ball, with a long metal nozzle. The nozzle is heated in a spirit-lamp flame, so that hot air can be ejected into a cavity by compressing the ball. It is well to remember that a very hot current of air often excites great pain, and is capable of giving rise to inflammation of a nearly-exposed pulp. It is never necessary to use excessive heat, although it is useful to apply greater heat in cases (to be described later) where the pulp has been destroyed and extirpated. It is often a good plan to direct the hot air round the external margin rather than into the depths of a cavity.

There can be no doubt that a surface of dentine dehydrated by the method described, will readily take up the alcohol with an antiseptic in solution on a second immediate application, and that the fluid will penetrate

* In using fluids which may irritate or excoriate the mucous membrane or skin, care should be taken to prevent them from flowing out of the cavity, perhaps along the shaft of an instrument, on to the gums or lips—an accident which often occurs in careless hands.

even healthy tubuli to some small depth, and will penetrate to a greater depth when these are occupied by organisms, as in the incipient stage of caries. Before the days when the existence of micro-organisms in the tubules in incipient caries was known of, dentine was with impunity left in that state in the depths of cavities; it can be the more safely left now, when its condition is perfectly understood, and the means of sterilisation are sufficient and at hand.

There are no grounds upon which the deliberate exposure of a healthy pulp during the process of excavation can be justified. It is probable that a healthy pulp, exposed to the atmosphere alone, and no other irritation, will certainly pass into a condition of disease if not kept aseptic by art. This always happens in the case of a joint, or other analogous structure, wounded in a like manner. The condition of an exposed pulp may be fairly compared to that of the tissues exposed in such a wound, or in a compound fracture. The difficulties of rendering an exposed wounded pulp aseptic, and of keeping it in that condition during and after filling operations, are very great. These are spoken of under the heading of treatment of exposed pulp. On the other hand, the existence of a layer of slightly affected tissue treated as described, and enclosed beneath a filling in the depths of a cavity, can be productive of no harm. If the tissue be cut away it must be afterwards replaced by an artificial substitute. The application of this is difficult, the operation often sets up inflammation, and even when of the most perfect construction, a "cap"—as it is called—must be necessarily less adapted to its purpose than a layer of imperfect dentine.*

* A paper read by Dr. Choquet, of Paris, at the International Dental Congress, 1900, and published (Dental Cosmos, October, 1900), whilst these sheets are passing through the press, deserves brief notice here. Dr. Choquet affirms that a recru-

In previous pages the sensibility of dentine in health and disease was described, and the fact was mentioned that the sensibility (which depends on the existence of a living pulp) varies very much in different individuals. Excision of carious tissue is thus always a more or less painful operation. In most cases, however, it will be found that it inflicts no more than an easily bearable amount of pain, when it is done rapidly with instruments thoroughly sharp, and used with an engine which runs true and with a minimum of vibration—the latter an important point. A tiny stream of water flowing over a revolving drill to prevent heating will often save much pain. Drop tubes to effect this are provided. In the few cases in which there appears uncommon sensibility or in which the patient cannot endure the pain, the suffering may be lessened by applications which diminish the sensibility of dentine. Amongst applications in common use may be mentioned chloride of zinc and arsenious acid. But these substances, especially the latter, must be used always with caution,

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descence of "destructive caries," may take place under good fillings of whatever material, after lapse of a long time. He believes that of the organisms left in the tubules of slightly affected dentine beneath an hermetic stopping, some may be either actually anærobic or facultative, and capable of adjusting themselves to their new condition and existing without oxygen. He believes these organisms are capable of softening dentine without access of moisture or other external agents. Dr. Choquet bases his opinion mainly upon experiments made on the teeth of sheep. He drilled holes into teeth, and after inserting a small portion of carious dentine in the depths, filled the cavities. After lapse of months the sheep were slaughtered, and it was found that the tubules of the walls of the artificial cavities were penetrated by organisms to some depth, and softening of dentine had also in some cases taken place.

There are some evident sources of fallacy in these experiments, and whatever scientific interest attaches to Dr. Choquet's observations, they cannot be considered to call for modification of the rule of practice above recommended. In cavities properly prepared failure of well-made stoppings from recrudescence of caries in the depths was an extremely rare occurrence, even in the days before antiseptic processes were understood or practised. It is doubtful whether any practitioner has ever encountered a single instance in which it could be proved that in an hermetically sealed cavity, having sufficiently sound outer walls and margins, caries had progressed beneath a stopping. With the means of sterilisation now

even in superficial caries, and being very apt to penetrate to the pulp and excite inflammation, they are entirely forbidden when the pulp is nearly approached by decay. Chloride of zinc may be applied in strong solution; or a minute quantity of the solid salt may be applied to and allowed to deliquesce on the slightly moistened surface. Of arsenious acid $\frac{1}{50}$ of a grain in fine powder would be a maximum quantity to use for obtunding purposes. This would be applied on a pellet of cotton wool, moistened with carbolic acid, sealed beneath a temporary gutta percha stopping and left for a few hours. It is the cutting out of the harder sound tissue in shaping the cavity which inflicts most pain, and it is a good plan in many cases to first remove the disorganised softened dentine, and then put in a filling of oxychloride of zinc cement, and leave it for a few days. This cement has some free chloride which acts upon the sensitive surface. The action of this cement as well as of the salt alone gives rise usually to smart pain, which however rarely lasts many minutes. Sensibility of dentine may be most safely and effectually lessened during excision by the use of absolute alcohol and the hot air syringe, as described in preceding paragraphs. Excavation will then be best done with the saliva entirely excluded throughout

at his command such a result need not be, and is virtually never considered by the practitioner. If organisms were sufficiently active in any number of cases, where a minute portion of infected dentine remained, such instances must be within the everyday experience of all. Where stoppings fail it may be said that, without exception, there always exists evidence of leakage around, or of penetration in some way through the joints of the fillings, or through defective surrounding enamel. Infection and inflammation of the pulp following stopping is a different matter; and it has been more than once pointed out that a pulp, covered with a thin layer of carious dentine, must be looked upon practically as "exposed," seeing that septic organisms can penetrate to its surface through the tubules. It is only in cases in which the decay, although deep, has not advanced to this latter dangerous point, that it often is expedient—although in relatively exceptional cases—to stop short of complete excavation of affected tissue.

the operation, although a very considerable effect may be produced by drying the cavity and applying alcohol at intervals. Some operators prefer always to exclude saliva throughout the operation of excising decay; and this plan answers well with sensitive dentine which needs obtunding. Methods of excluding saliva are explained on a later page.

In excavating the tissues preparatory to the insertion of filling it is not only necessary to remove decay, it is necessary often to cut away a considerable amount of sound tissue to render access to the cavity sufficiently easy, and it is mostly necessary to modify the form of the cavity to adapt it for the retention of a stopping. It will be presently seen that with one exception no class of materials used in filling teeth adhere as cements to the walls of a cavity—they are all retained by either plugging, wedging, or dovetailing. The simplest kinds of cavities are such as after removal of the decay assume the form of a hole or trench with vertical walls; and those which require most modification are such as have a narrow irregular orifice, and those which either wholly or partly take the form of a shallow saucer-shaped excavation. To pack a filling beneath the overhanging margins of a cavity being often impossible, these portions must be, when necessary, freely cut away, whilst, as it is also impossible to fix a plug upon a shallow concave depression, the walls of such a cavity must be rendered either vertical or slightly undercut, or retaining points must be formed. Retaining points are made by drilling small pits in different parts of the cavity. Into these pits portions of filling are packed, and to these portions more and more being securely joined, the whole mass is fixed immovably in position. The number, size, and depth of retaining points must be regulated according to the circumstances of the case. They need never be very

deep, and of course due care must be taken in using drills to avoid closely approaching or laying open the pulp cavity.

Carious cavities present an infinite variety of differences in minute details of form; but from a practical point of view in relation to the operation of stopping, they may be divided into comparatively few classes, having features alike. With rare exceptions, all cavities in the earlier stages of decay are surrounded by solid walls, and when excavated assume the form of holes, more or less irregular in shape and outline, both without and within. In these instances, the filling operation consists merely in plugging the hole from which decay has been excised, and of which the walls have been shaped to retain the stopping. In the case of incisors and canines, by far the greater number of cavities occur on the mesial and distal surfaces, usually closer to the neck than to the cutting edge. The amount of dentine between the outer walls is in these situations small; and the cavities soon are left surrounded either entirely or to a great extent by enamel alone. If decay still goes on unchecked, the enamel becomes reduced to a thinner and thinner shell; and at last begins to break away. The ragged orifice of the cavity thus becomes enlarged towards other besides the lateral aspects, usually on the lingual or labial face of the tooth. The stopping problem then resolves itself into the building up of a filling from the solid remaining foundations to restore the contour of the crown.

If the walls of cavities in incisors and canines formed of enamel alone are not actually carious, they can, in many instances, be preserved, when reduced to even extreme thinness. In leaving fragile walls in these teeth, which is often desirable for the sake of appearance, the operator must be largely guided by the peculiarities of the bite. Front teeth very often are so disposed with

the operation, although a very considerable effect may be produced by drying the cavity and applying alcohol at intervals. Some operators prefer always to exclude saliva throughout the operation of excising decay; and this plan answers well with sensitive dentine which needs obtunding. Methods of excluding saliva are explained on a later page.

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regard to their opponents in the other jaw, that weak walls may be left, which could not be trusted to stand in any situation exposed to force during mastication. In a large proportion of cases in upper incisors and canines the lingual surface of cavities becomes earliest destroyed; and the labial wall being least liable to injury and more necessary for appearance can be preserved.

Sometimes weak walls of front teeth may be strengthened and supported by a buttress or lining of cement, which being kept sufficiently below the external margin can be effectually sealed beneath a gold filling or a porcelain inlay.

In molars and bicuspids the cases are extremely rare in which the masticating surface of a crown cavity can safely be left without a wall well supported by a considerable thickness of dentine within the enamel. A thin shell of enamel in such a position is certain before long to be crushed in by the impact of the teeth upon hard particles of food. The crown must be cut through in these cases, and the stopping built up from a foundation solid enough to withstand the strain to which it will be exposed. The lateral walls of a cavity in a bicuspid or molar must, for similar reasons, always be stronger than may be necessary in a front tooth ; and at the point where they approach the grinding surface can hardly ever be left safely of enamel alone. Decay in bicuspids, in the great majority of cases, begins on approximal surfaces ; whilst in molars the starting place is, as often as not, the sulci between the cusps on the masticating surface.*

* It is impossible to lay down anything approaching to fixed or arbitrary rules with regard to the opening up and shaping of cavities preparatory to filling. Cases vary infinitely in minute details, and each calls for the exercise of, at least, some judgment and discretion. Excavation of cavities in extracted teeth as suggested at the opening of this chapter, is of great educational value in these operations, especially in training the eye and hand to distinguish by sight and touch, carious enamel and dentine from sound tissue.

The following series of diagrams, with description of typical cavities, may serve to make this subject more clearly understood. Fig. 157 exhibits the aspect of the commonest form of simple cavity in the grinding surface of a molar. In such a cavity the overhanging enamel would require cutting back to the extent shown

FIG. 157.

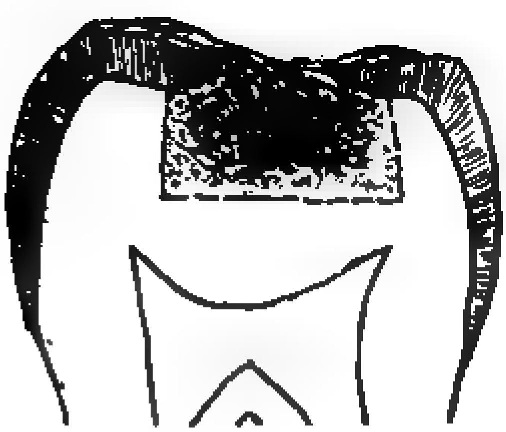

FIG. 158.

FIG. 159.

by the dotted lines. A section of the same tooth through line A—B (fig. 158) shows about the extent to which decay in such a case usually extends beneath the enamel. Fig. 159 shows section of same tooth, and illustrates the preparation of a typical cavity for filling with cohesive gold. The walls are slightly divergent

towards the floor of the cavity, sufficiently to give a wedge shape to the filling. On the other hand, the enamel walls are bevelled back at the orifice sufficiently to avoid leaving a sharp edge against which it would be difficult to pack cohesive gold without chipping the

FIG. 160

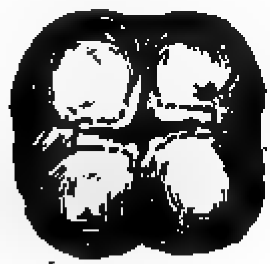

FIG. 161.

enamel. If the cavity were intended for stopping with non-cohesive gold, or any other filling, particularly amalgam, the edges should not be bevelled back, but should run in a line with the dentine walls. A thin overhanging edge of amalgam round the plug is likely,

FIG. 162

owing to the brittleness of the material, to break gradually away and leave a rough margin.*

Fig. 160 illustrates the preparation of a cavity when the decay is situated in the fissures of the crown of a

* The materials used for stoppings are described in later paragraphs.

molar. The dotted lines indicate about the extent to which it is usually necessary to cut back the enamel walls. Fig. 161 shows the same cavity prepared. In cutting out such a cavity care should be taken to leave no sharp corners; they should all be well rounded off,

FIG. 163.

to facilitate packing of the stopping. Fissures radiating from the cavity in every case in any tooth must be laid open throughout their entire length. It will be often found that they extend outwards and terminate beneath the enamel close to one or other external surface; and through that surface they must be opened, as well

FIG. 164.

as through the crown. It is seldom necessary to carry the excavation of a fissure as deep as the main cavity. The excavation often runs at an angle with the main cavity, and forms what is called a "step." The step may serve to lock the filling securely in place. It also

takes part of the strain during mastication—strain which tends constantly to force the filling from its anchorage. Fillings showing the "step" are seen in figs. 173 and 194.

FIG. 165.

Fig. 162 illustrates, after preparation for filling, a cavity of typical form, of common occurrence in molars and bicuspids at one or other angle of the crown. Such a cavity can often be formed to hold a filling securely without undercuts or retaining points.

FIG. 166.

Fig. 163 shows a cavity after excavation on the distal surface of an incisor. The cavity is of some slight depth towards its centre, but from that point slopes

gradually in every direction towards the lingual and labial margins, and towards the cutting edge and neck of the tooth. It forms, therefore, a uniformly concave saucer-shaped cavity, incapable of retaining a filling. Such a cavity might well be prepared by giving it the form of a trench, as shown in fig. 164, with slightly undercut walls, rendering it a little smaller at the orifice than within.

The next diagrams illustrate the formation of retaining points. A cavity of typical character on the distal surface of an incisor is shown in fig. 165. After removal of the carious tissues it forms a shallow concavity, broad at the upper part and sloping and narrowing towards the cutting edge of the tooth, near which point it terminates. The preparation of such a cavity would consist, after slightly deepening the labial and lingual walls, in drilling two pits as shown in fig. 166 in the upper aspect, and one in the lower angle, of the depth and in the direction indicated by the dotted lines.

In the examples just illustrated the cavity is bounded by four solid walls; in the following there are only three walls, and consequently the mode of preparation is modified in some details.

Fig. 167 is an example of decay occurring in the side of an upper bicuspid. In these situations, and particularly with cavities on distal surfaces of bicuspids and molars, it is generally necessary to cut through the masticating surface of the crown in order to get free access to the cavity, and to permit of the packing of a solid plug. It has already been stated and it may be well to repeat that enamel, forming the grinding surface of a bicuspid or molar, unsupported by a considerable thickness of dentine, will not long withstand the force of mastication, even after insertion of a filling, and for this reason alone must be in many cases cut away. Small cavities,

particularly on mesial aspects and where decay has not closely approached the masticating surface, may, however, often be effectually treated without cutting through that surface. The dotted lines indicate the extent to which it is usually necessary to cut back the enamel walls in the case illustrated. This being done and decay removed, the cavity must be shaped as shown in fig. 168 and in section in fig. 169, in which F indicates the floor

FIG. 167. FIG. 168.

FIG. 169.

of the cavity. The floor of the cavity should be slightly wider than the mouth, and at the junction of the side walls with the inner one, retaining grooves should be cut as indicated in dotted lines in fig. 168 and G in fig. 169. At the bottom of these grooves, retaining points should be drilled, figs. 168 and 169, P P. The edges of the cavity should be finally rounded and well smoothed off.

In figs. 167 and 168 the drawing suggests the existence of a fissure running across the sulcus between

FIG. 170 FIG. 171

the cusps, towards the further side of the tooth. Such a fissure would need to be opened up and would then

FIG. 172. FIG. 173.

form a "step." The utility of a step in securing a stopping has been explained in a recent paragraph.

Figs. 170, 171 and 172 illustrate the preparation of a cavity where a portion of the side and cutting edge of a tooth are destroyed, and consequently part of the filling has no supporting walls.

The dotted lines in fig. 170 show the extent to which the enamel walls will have to be cut back in the preparation of the cavity.

Fig. 171 displays a front view of tooth with cavity prepared showing the extent of tissue removed. The dotted lines indicate the depth of the groove which has been cut in the sound dentine after excavation of the cavity—a groove which with retaining points is to hold the foundations of the stopping.

Fig. 172 is a side view of same tooth showing cavity prepared.* Fig. 173 shows the posterior view of a similar case, in which it has been possible to form a "step" or return angle; thus adding to the strength and stability of the filling. In preparing a cavity of this nature for gold, if after the removal of decay there is left only a thin shell of enamel unsupported by dentine at the cutting edge, it will, in most cases, be necessary to cut it away, as illustrated in figs. 171 and 172. It is often possible to carry a buttress of cement from the depths of the cavity against the fragile wall to some distance below its external edge, and so strengthen the wall as to permit of the building up of the tooth with cohesive gold. A thin shell of enamel in an incisor or canine which would not bear the force necessary in packing gold, may often be preserved by use of plastic cement and gutta percha, or by a porcelain inlay.

In order to secure a gold plug in such a cavity it will

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* The outline of the cervical margin of the cavity depicted in fig. 172 is very concave. This form is apt to lead to "rocking" of the stopping, and the shape of the cavity at this p rt ought to be as flat as possible. The proper form of the cervical margin is shown in figs. 166 and 168.

be necessary to excavate an undercut groove all round. This groove should be cut in the dentine between the enamel and the pulp, so as to leave a supporting layer of dentine under the enamel and a protecting layer over the pulp, see figs. 172 and 194, in which the groove is marked G and U respectively. Three retaining points must then be drilled in positions indicated in figs. 171 and 172, marked A A A, care being taken not to approach the pulp or crack the enamel. Preparation of the cavities of this type is designed to provide for fixation of an immovable wedge-shaped mass of gold in the depths, upon which can be built more and more until the tooth is restored to its original form.

The later section on gold filling will be further explanatory of this subject.

Separating Teeth.—The difficulties which present themselves in dealing with cavities, which, being situated on the contiguous surfaces of teeth, are neither fully visible nor sufficiently accessible, must be overcome either by free chamfering, or by temporarily forcing the teeth apart. The beneficial effect of permanently separating teeth was explained in the section on the treatment of incipient caries, and the procedure there described must be adopted in the majority of cases preparatory to the filling of the cavities in question. In treating incisors and canines the plan described in the section on incipient caries must be adhered to, and the chamfering must be as far as possible confined to the lingual aspect of the teeth. This suffices in most cases to render the cavity accessible to the filling instruments from behind, whilst the labial surface remaining intact, the normal appearance of the tooth is preserved, and the filling, unless large, is rendered invisible to casual observation. The instances in which it is better to force the teeth temporarily apart are

those in which small cavities exist in teeth—especially front teeth—of otherwise sound structure, and where permanent separation would cause disfigurement. Sometimes the plan may be well adopted of chamfering the affected surfaces to some extent, and pressing the teeth apart in order to obtain the further space necessary for the use of the filling instruments.

The temporary separation of front teeth—incisors, canines and bicuspids, is easily effected by slipping between them a strip of india-rubber, and allowing it to remain for twenty-four hours. A very slight amount of pressure suffices for the object; the rubber should not, therefore, be thicker than the space which it is desired to make, and this space should not be greater than suffices to allow the use of the necessary instruments. If much force be exercised great pain is set up, and the presence of the rubber soon becomes intolerable. After the removal of the rubber, the teeth fall together again in the course of a few hours, and the tenderness which the process has caused also rapidly subsides.

A similar effect can be produced by packing a plug of gutta percha, or of cotton wool saturated with mastic cement, between the teeth, and allowing it to remain for a few days, renewing it at intervals till the desired effect is produced. This plan is preferable with the molars, and also in cases in which a mass of swollen gum, which bleeds easily, projects into the cavity. Pressure of a plug of this kind causes masses of swollen gum gradually to shrink, leaving a clear way for the use of instruments.

In cases where the patient cannot endure the pressure of a strip of rubber between the teeth, separation can be effected more gradually and less painfully by narrow cotton tape. The patient may insert one thickness between the teeth, and after a few hours he will be

able to double the tape, and so can go on gradually increasing the number of folds until he has used the number directed; three folds of tape are generally sufficient. It is often well after wedging teeth to insert a temporary filling for a few days, occupying the space obtained, so as to keep the teeth apart. This will give time for tenderness to subside, and will prevent pain from the pressure in condensing gold.

During the subsequent steps of a filling operation in interstitial cavities, the insertion of a wooden wedge between the necks of the defective teeth is often useful. A piece of compressed hickory of suitable size is cut so as to fit with a moderate degree of tightness the V-shaped space which naturally exists between the necks of the teeth. This is steadily pushed between the teeth, and the ends being cut short, it is allowed to remain until the filling is completed. The use of a wedge alone in this manner, in some cases in which the teeth are not closely in contact, is sufficient to afford room for the satisfactory performance of a filling operation. In using wooden wedges or screw separators, which also are sometimes employed to press teeth quickly apart, great care must be taken to avoid excessive force, for this, especially in youthful patients, may excite periostitis, which, lingering in a chronic form, may lead, if not to the immediate loss, to permanent looseness and tenderness of the tooth. The wedge often subserves the purpose of forcing away the gum and preventing it from bleeding, and from being wounded by files and other instruments; whilst the tooth is steadied, rendered more able to bear the force of plugging, and pain is thus diminished. A wedge also often serves to hold in position the rubber dam and a matrix.

When carried out on the principles laid down in the section on treatment of incipient caries, the

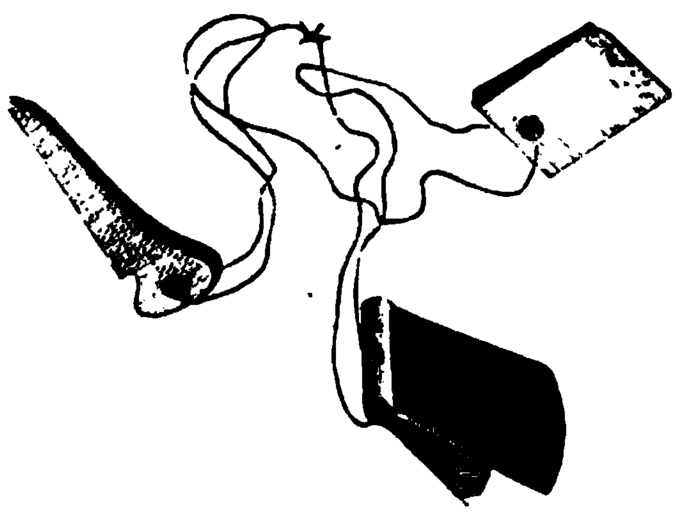
making of permanent spaces by chamfering the surfaces is productive of nothing but good as a rule with the six front teeth; food is not apt to lodge for long in those positions, and with this plan stoppings are less visible and disfiguring. But in a considerable number of instances, spaces between grinding teeth are productive of discomfort to the patient, and this may be considerable or even intolerable in unfavourable circumstances. During mastication, food is apt to be gradually forced into the spaces, until the mass pressing upon the gum and neck of the tooth gives rise to great uneasiness or pain. To avoid this the chamfering ought, when possible, to be so done as to allow the space to be easily cleared by the tongue, and, indeed, often the surfaces can be so bevelled that the difficulty is reduced to a minimum. The best treatment of interstitial cavities is by construction of what are termed "contour-fillings"—fillings which restore the original contour of the tooth. These are described and illustrated on a later page. Such fillings call for skill and labour, and unless perfectly constructed they give rise to evils. With a wide space between the teeth the patient will be conscious of the lodgment of particles, and may take care to remove them; but with badly-made contour-fillings, *débris* is likely to lodge and remain without the patient being aware of its presence, and decay will probably be soon started, and at the part most difficult of access—the neck of the tooth at the line of the gum.

Use of the Matrix.—When the contour of a tooth needs restoration, the use of a matrix or artificial wall, against which a filling can be packed and which can afterwards be easily removed, is of great service.

Where there is only a small division between the teeth, a thin piece of polished steel can be cut to size and slipped

between. Strips of steel of different widths and thicknesses can be obtained from instrument makers, and a piece should be selected wide enough to extend from below the cervical edge to the mouth of the cavity, and of a thickness sufficient to fit tightly between the teeth, or it can be fixed by a wooden wedge. A simple form of matrix, the character of which is made clear by the illustration, is shown in fig. 174. Two sizes are enough for a large number of simple cases. The wedge (shown in the cut) is used when necessary to fix the matrix. Where lingual and labial walls are destroyed to any considerable extent, a flat-sided matrix will not serve if

FIG. 174.



a contour filling is to be built. In these cases, the matrix must provide a concavity of sufficient depth to allow of the building out of the stopping. Miller's matrix is specially adapted for cases of this nature. It is made in numerous shapes and sizes and in sets, so that one can be usually selected to suit any case. Fig. 175 shows this matrix in position and also two forms of the matrix.

Where the tooth is isolated, or there are no neighbouring teeth to help retain the matrix in position, a matrix as shown in fig. 176 may be used. It consists of a shaped steel band, which is passed round the tooth

and kept in position by a screw clamp. Fig. 176 shows the band and clamp and the matrix in position. A variety of sizes to suit different teeth are manufactured.

A convenient form of matrix (Ivory's) adaptable to molar or bicuspid teeth on either side of the mouth, and in either upper or lower jaw, is shown in fig. 177. It consists of a strip of thin metal perforated at its extremities, and fixed in position by a clamp with adjustable arms. The method of using it is simple. A strip of metal of the depth necessary to reach from the highest to the lowest point of the cavity to be filled,

FIG. 175.

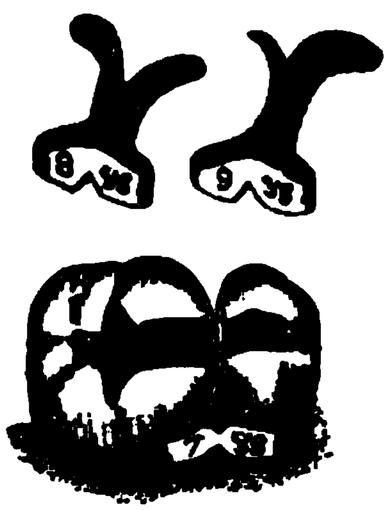
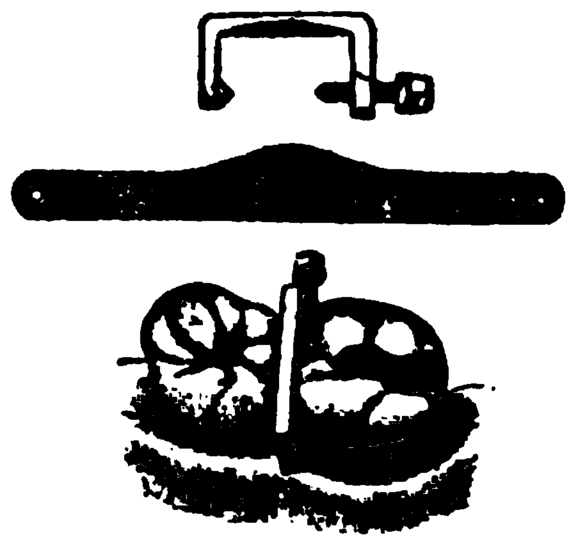


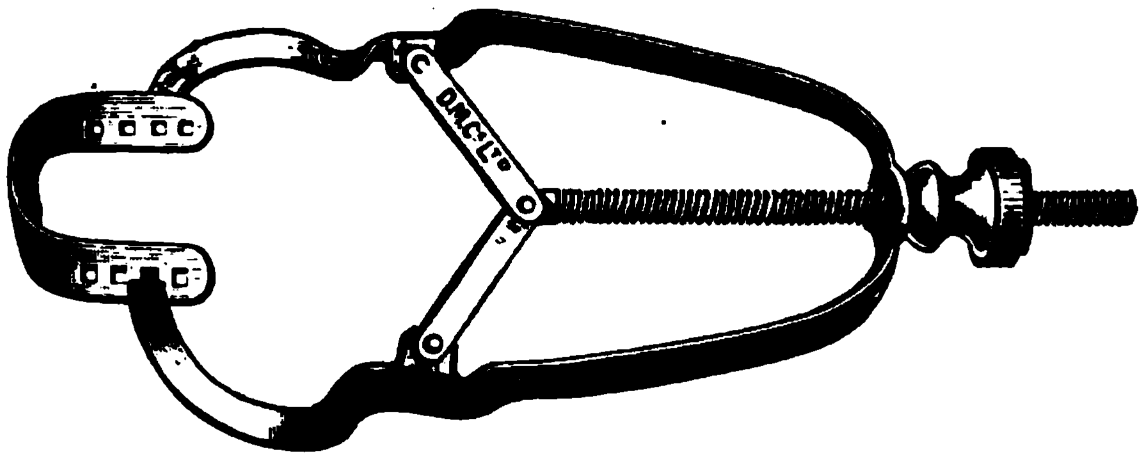
FIG. 176.



being fixed to the arms of the clamp in the manner shown in the engraving, is passed round the tooth, and drawn tightly up to its walls by means of the screw-head, revolution of which shortens the distance between the arms of the clamp, and retains the matrix in close apposition to the walls of the cavity. It is necessary to use some caution in removing such matrices when using them with plastic fillings, or the filling may be disturbed, if not partially dislodged. To avoid this accident a matrix may be left in position on the tooth until the filling has completely hardened. When it is desirable to do this some other form of appliance, of which there are several, must be employed.

Mr. Lennox, of Cambridge, has described a method of making matrices which possess the advantages of removability or of retention. He has shown incidentally that the true form of a matrix should be a segment of a flat ring; and that all teeth whether molars or bicuspids require part of the same ring. He has ascertained the size of this ring, and it is only necessary to possess matrices of about three sizes cut from such a ring, to be in a position to deal with all cases. The contrivance (fig. ·178), resembles somewhat the Ivory

FIG. 177.

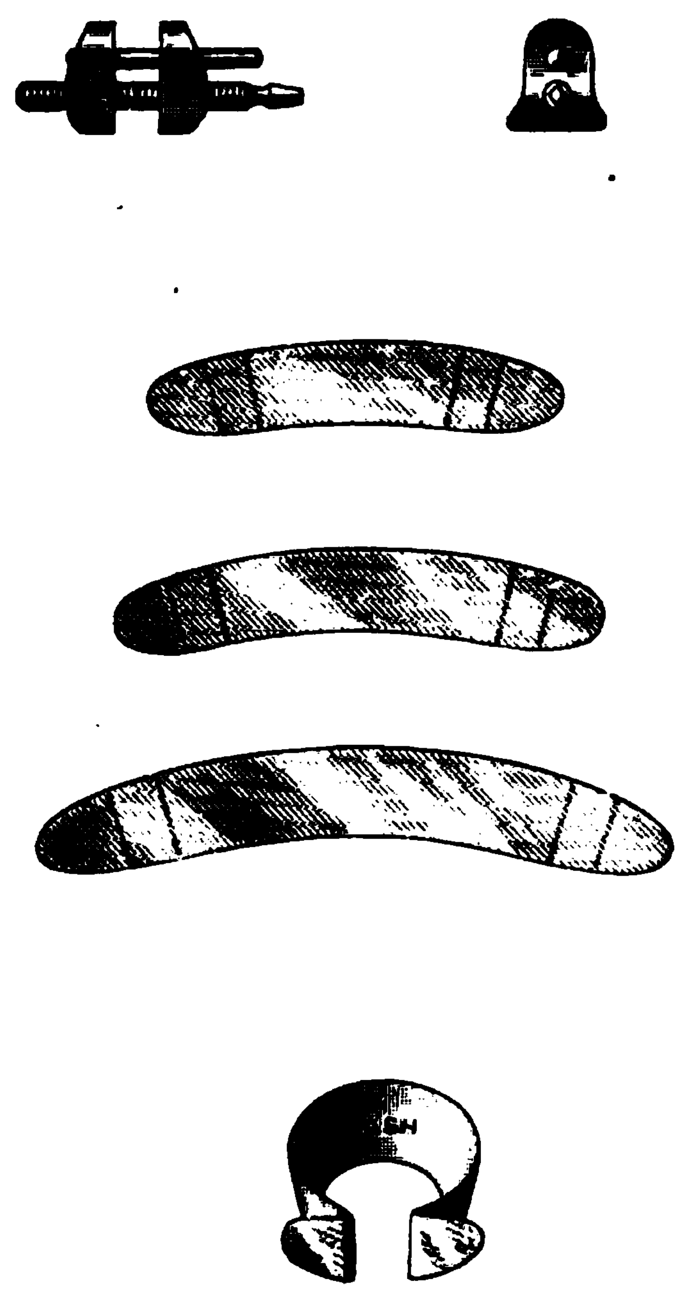


matrix, but instead of being perforated the ends are bent back, and are retained when in position on the tooth by a clamp or double acting parallel vice. When it is desired to retain the matrix after removal of the clamp, binding wire is passed over the bent ends or lugs of the matrix, and the ends of the wire twisted together and being tightened up, any superfluous metal or wire may be cut away. The whole is removed on a later occasion when the filling is thoroughly set. Where necessary the matrix may be shaped on a specially devised mandrel, and a groove given to it corresponding to the groove so often found running down the sides of many teeth, especially upper bicuspids.

A little ingenuity will enable the student or practitioner to devise a matrix for any case—and they will be found very few in number—in which one or other of the

foregoing contrivances are insufficient or unavailable. It is an exceedingly simple matter from a sheet of thin German silver or of metal specially supplied for the purpose, to cut a strip suitable for the case in hand, to

FIG. 178



shape it with scissors and pliers, and either solder it and slip it over the tooth to be filled, or wedge it in position by means of a wooden wedge, a pledget of cotton wool, or temporary stopping. A more accurate fit may be obtained by first taking a pattern in thin lead foil and shaping the metal to this.

This kind of matrix possesses, in common with Mr. Lennox's, the advantage over most others in that it can be left in position; and when a large portion of the crown and side of a tooth has to be restored with amalgam, it does away with risk of the stopping being dislodged before it has had time to set and harden. The necessity of leaving a matrix on the tooth for more than a short time has been lessened by introduction of quick-setting amalgams. But even with these it is often not safe to leave unsupported a large newly-made stopping, which receives the impact of opposing teeth. An amalgam on first setting may remain for a time in a friable or brittle state, easily split by sudden pressure, as by a hard particle of food between the teeth. In some cases—particularly large contour fillings—it may often be best to leave the matrix in place for at least twenty-four hours.

The presence of a matrix is apt to give the operator a false impression of solidity in the plug whilst building up a filling, and particular care must be taken in packing gold against the artificial metal wall. It is well to remember in connexion with gold fillings that the matrix should not be too rigidly applied to the edges of the cavity, but should be so adjusted that gold may be built over the external enamel margins.*

Drying the Cavity.—The cavity having been prepared for the reception of a filling, the next step consists in drying it and guarding against the access of moisture until the completion of the operation. The difficulty in accomplishing the latter part of this process is much greater in every case at some positions in the mouth than at others, whilst the extremely profuse flow of

* A great variety of useful matrices, and instruments used in applying them devised by different operators, are figured in the catalogues of instrument makers. Small shears, pliers, &c., are also made for cutting and shaping matrices from sheet metal.

saliva in certain patients is even under favourable circumstances hard to control. The teeth situated at the anterior part of the upper jaw are the most easily managed, the orifices of the salivary glands being distant, and the fluid naturally gravitating towards the back of the mouth. In most cases, during the filling of the upper incisors, canines, or bicuspids, the cavity may be kept dry by the insertion of a folded napkin beneath the lip, and across the lower front teeth, to prevent the tongue from carrying up moisture from beneath. The most useful form of napkins are made of moderately thick diaper, and measure from three to four inches in breadth, and from six to eight inches in length. This material, if kept free from starch in washing, will be found highly absorbent. The napkin can be folded or twisted into a loose coil, and as it becomes saturated with moisture a dry one may easily be substituted without permitting the access of saliva to the tooth. Patients who cannot swallow with the mouth open may sometimes be allowed at intervals to close the lower teeth upon the folded napkin aud so get rid of the accumulated saliva.

The duct of the largest salivary gland—the parotid—opens through the mucous membrane of the cheek, where it lies against the upper molars, and its flow must therefore be directed or controlled before these teeth can be dried. Where the flow is not profuse, and particularly when the cavity is situated on the masticating surface, precautions such as described for the front of the upper jaw may suffice. A folded napkin may be laid between the cheek and alveolar border, and held in position by the fingers of the left hand. In other cases these measures may be supplemented by the temporary closure of the orifice of the duct. This may be accomplished by the application of clamps specially

contrived for the purpose, or the exit of saliva may be sometimes prevented temporarily by a small patch of impervious sticking plaster.

In the lower jaw the exclusion of saliva during plugging presents more difficulties than in the upper. The saliva naturally accumulates on the floor of the mouth, and the movements of the tongue and the efforts of swallowing have a constant tendency to throw it over the crowns of the teeth. In patients who cannot swallow with the mouth open the difficulties are increased. Where the tooth has to be kept dry for no

FIG. 179.

more than a few minutes, the influx of saliva may be guarded against by the insertion of a roll of napkin beneath the tongue and between the cheek and side of the jaw, the rolls being firmly held in position by the fingers of the left hand. It is important to apply the napkin to the floor of the mouth and not to attempt to hold down the tongue. Clamps are now to be had which hold a napkin or folds of cotton around the tooth, whilst leaving the crown free of access to the operator. A simple contrivance of this kind, one of many equally useful, is shown in fig. 179 In some

cases an intelligent and steady patient may be trusted to hold a folded napkin with the fingers of the hand which least comes in the way of the operator. The patient may pass the fore-finger over the teeth and press down the napkin, whilst with the other fingers and thumb he grasps the lower jaw. In this position the arm may be allowed to rest on the chest. With the lower jaw steadied in this way many patients are enabled to swallow with the jaws apart and are thus able to get rid of the saliva. An instrument is made which consists of a flat metal band designed to lie within the lower jaw and hold firmly down a roll of napkin beneath the tongue. The band by a shaped arm passing over the front teeth is attached to a padded frame under the chin. A screw draws the parts together and provides the necessary pressure.

In the majority of simple ordinary cases it will be found possible to keep the tooth dry during the insertion of dressings and small uncomplicated fillings by the means just described, which were those alone available until late years. There has, however, been introduced within late years the contrivance known as the rubber dam. This simple invention enables the dentist to keep a tooth perfectly dry throughout the most prolonged operation. The dam is formed of a thin sheet of india-rubber specially prepared for these operations. A piece is taken a few square inches in size, and towards its centre is punched a small hole, one about as large as an ordinary pin head being big enough for a molar. This hole is stretched and slipped over the tooth, so that the rubber closely embraces the neck and leaves the crown surrounded by an impervious dam. In practice, it is found necessary to make a series of holes in the rubber, the same distance apart as the crowns of several of the teeth adjoining the one to be operated upon, and

to pass the rubber over them also. By this means, the rubber is securely fixed and kept effectually out of the way.

Difficulties in applying and securing the dam arise where the teeth are in extremely close contact, and where, from the conical shape of their crowns, the elasticity of the rubber causes it to spring off. The first of the difficulties may be overcome by forcing down the highly stretched rubber by a thin strand of waxed floss silk. It is found that by the pressure of the tense thread the teeth can be forced slightly apart at the point where their crowns are in contact at the masticating surface, and this point being passed, the rubber is readily carried down to the gum, at which position an interval invariably exists between the teeth.

In operating upon interstitial cavities it is advisable before applying the rubber to pass a waxed silk thread between the teeth and ascertain that there are no sharp edges to split the dam while being placed in position. Tartar round the necks of the teeth likely to prevent either clamp, rubber or ligature from passing to its proper position at the neck of the tooth at its narrowest part must be removed, and this is of special importance with cavities in lower front teeth. To prevent the dam from springing off the tooth a steel clamp of suitable design may be used. Clamps are applied to the teeth with the aid of clamp-forceps. With these the clamp is carried to its position, opened and slipped over the tooth. The clamp grips tightly the neck of the tooth, and forms a projecting flange, under which the rubber slips, and is thus held secure. A great variety of clamps have been designed for this purpose, and a little experience will soon teach the student those best adapted for his purpose. Figs. 180 and 182 illustrate two clamps (Buckman's). Fig. 182 is designed for molars and fig

180 for bicuspids. Fig. 181 shows the bicuspid clamp *in situ*. In the drawing showing the application of the rubber dam, fig. 183, the molar clamp is seen in position.

Having ascertained that the clamp fits the tooth firmly and will not spring off, the operator should fix it in position, and having punched clean holes without any cracks (which would cause the rubber to tear when stretched), he should with his two forefingers stretch the rubber and slip it over the bow of the clamp and then under the flanges. He should then in a similar manner slip the rubber over a sufficient number of contiguous

FIG. 180

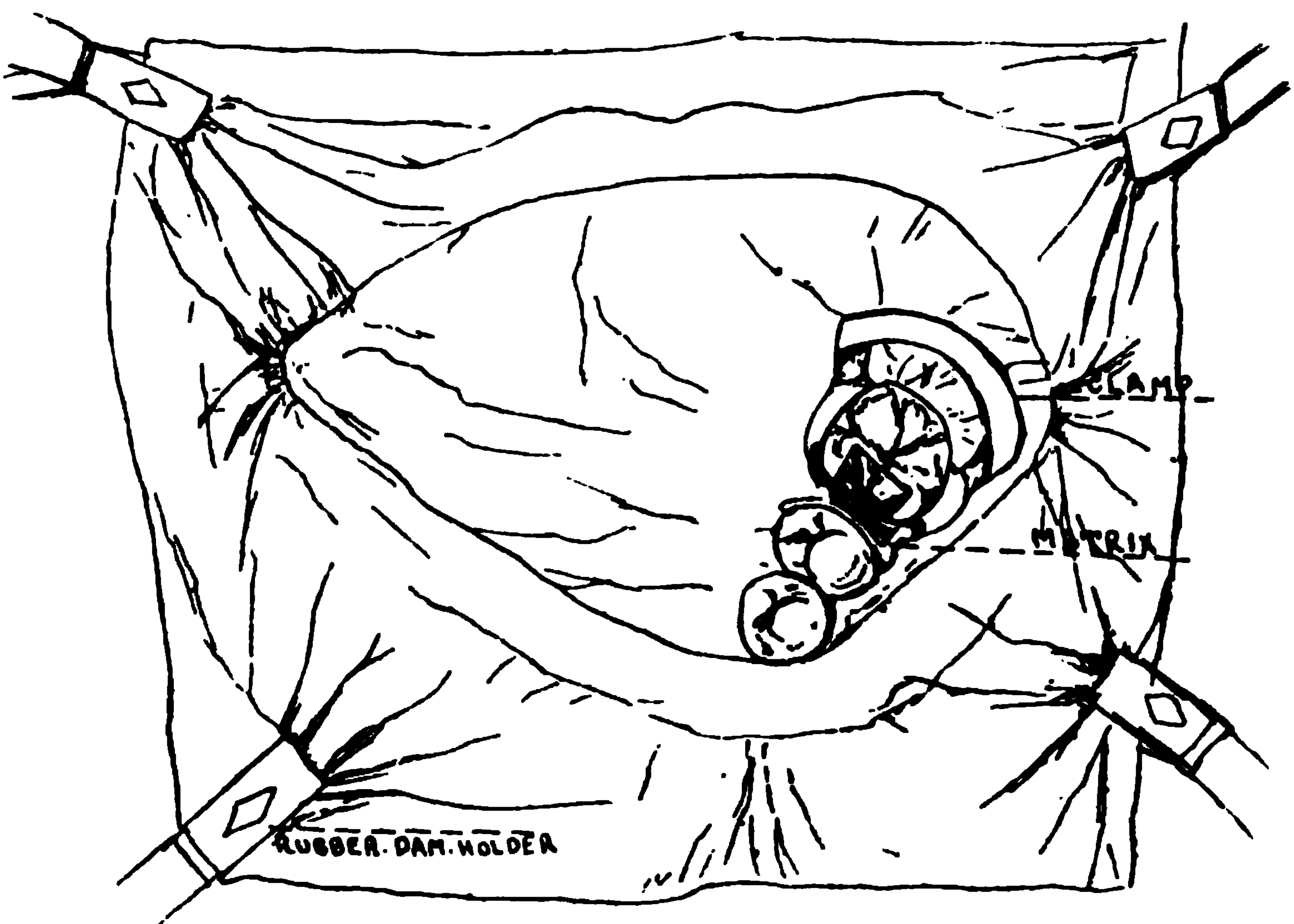
FIG. 181.

FIG. 182.

teeth, so as to give him a clear view of the tooth to be filled; and as he slips the rubber over tooth after tooth he will find it usually necessary to carry it down between the teeth by means of silk thread. The thread is best left in each space until the rubber has been passed over all the teeth. The silk ligature must next be passed round each tooth once or twice, so as to carry the rubber below the edge of the gum. It can then be tied tightly with a surgeon's knot. It is important that this should be done to each tooth, for if the rubber be not tucked under the free edge of the gum moisture may ooze through. Should the clamp spring off, the ligatures will retain the rubber in position until the clamp can be reapplied. Should the operator not be able from the

position of the clamp to pass the rubber over it when it is fixed on the tooth, the flanges of the clamp may be passed through the hole in the rubber; the whole may then be fixed with the aid of the clamp-forceps. Care must be taken to neatly wrap the rubber round the blades so that it will not obscure the view whilst fixing the clamp on the tooth. The clamp being fixed in

FIG. 183.



position the rubber can be slipped easily under the flanges and fixed as described previously.

Fig. 183 shows the rubber dam in position, held back neatly out of the way by two bands, one running round the back of the patient's head, the other round the neck. A molar clamp is shown in position, also a matrix (Miller's). The rubber is passed over the bicuspids so as

to give a clear view of the cavity. When used in conjunction with the dam, a matrix is, of course, to be adjusted last, and with a wedge it assists to keep the rubber secure. The whole diagram illustrates a cavity in a left lower molar prepared and ready for the insertion of a filling.

The rubber dam gives less annoyance to the patient whilst answering the purpose better than any other contrivance of the kind, besides which it leaves both hands of the operator free for the manipulation of stopping instruments. As an adjunct to the rubber dam, several ingenious hydraulic automatic saliva-ejectors have in late years been introduced. As the water accumulates on the floor of the mouth the ejector carries it off through a curved glass syphon tube which hangs upon the lower front teeth. These contrivances do away with the necessity of swallowing, and prevent discomfort arising from flow of saliva out of the mouth.

In cases which do not need the rubber dam, the operation being of short duration, the saliva ejector may often be used with advantage. This contrivance, in fact, very often renders application of the dam superfluous, the influx of saliva upon the tooth under operation being prevented by a folded napkin held in place by one of the instruments devised for this purpose ; or the ingress of moisture being guarded against by one or other of the simple measures described in the opening paragraphs of this section.

The influx of saliva having been guarded against, the cavity has next to be dried—a comparatively easy matter. It may be done roughly by wiping the surface with absorbent cotton wool, or with bibulous paper, or amadou. It is, however, by no means easy to procure perfect dryness by mere wiping with these materials. Better to achieve this end several varieties of hot-air

syringes have been devised, by which the moisture may be driven off by a current of heated air. These instruments are assisted in their action by the use of absolute alcohol. The properties and uses of this agent as well as the hot air syringe, have been described on a recent page. When applied to a wet surface, the alcohol, having a great affinity for water, combines with it, and evaporates. In this way it not only carries off superficial moisture, but it also abstracts water which the tissues intrinsically contain. Cavities to be dried with this fluid should be first wiped out with wool, and then swabbed with a small pellet, saturated with alcohol. After a pause of a moment to allow the spirit to unite with the water, the cavity can be again wiped with dry cotton, or the hot-air current may be thrown in. Rectified spirits of wine of ordinary strength, freely used, suffices for the purpose when the tissue to be dried is healthy, and not scftened or saturated with water. The swabbing and wiping and drying with heated air can be repeated when called for, as in those cases already referred to under a previous heading, in which it is desired to harden a layer of dentine the seat of incipient caries, which, to avoid too nearly approaching the pulp, must be left in the depths of a cavity beneath a filling. Like every other fluid which has a strong affinity for water, absolute alcohol will, of course, produce irritation if allowed to flow upon the skin or mucous membrane, although this will be but slight if the surface be wet and the quantity of spirit small. Accidents of this kind need not happen if ordinary care be taken.

The Materials used in Filling Teeth may be conveniently arranged for the purpose of description according to their durability in the mouth. One (gold) only is practically imperishable; several others, although subject to slight physical and chemical changes, are

sufficiently lasting to deserve the name of permanent fillings; whilst a third group, being liable to more rapid decomposition, must be classed as temporary fillings. Permanent fillings are, of course, always intended to act as permanent substitutes for the tissues destroyed by disease. Temporary fillings—as was noted incidentally in the section on excavating the carious tissues—are used in the preparatory treatment of cavities. Further explanation of their employment in the same and in other ways will appear in after chapters.

Gold used for filling teeth is pure—without any alloy whatever—for in this condition alone it possesses the qualities necessary for the production of perfect plugs. It is prepared by the manufacturers in two forms—in foil and in a spongy mass. The leaves are produced by beating, the sponge is formed by precipitating the metal from a solution. The leaf gold suitable for filling teeth is much thicker than that which is used in gilding, and comes to hand in sheets about four inches square, the lightest of which weigh four grains. Thicker qualities are made to suit the fancy of different operators, and the exigencies of cases. Sheets from four to six grains in weight are the most generally useful. Two qualities of gold foil are manufactured for dental purposes, non-cohesive and cohesive, and these differ in the fact that pieces of the former pressed together do not cohere, whilst portions of the latter forced closely into contact become inseparably united. These peculiarities are due to difference in the molecular condition of the foils, the cohesive variety being more crystalline in character than the non-cohesive. The cohesive quality of all foils is increased by annealing, and the non-cohesive variety may be rendered cohesive by the same operation. Annealing is performed either by heating the gold upon a metal tray, or by passing pellets through the flame of

a small spirit lamp when conveying them to the tooth. The cohesive property of pure gold (when in a certain molecular condition) is one that it possesses in common with some other metals, such as platinum, silver, tin, and lead, which are comparatively soft at ordinary temperatures. The cohesion is in fact due to welding, the metals being capable of union of this kind when in their cold state, just as iron and some others are when rendered plastic by heat. Sponge gold, owing to its perfectly crystalline form, is the most cohesive variety prepared for dental purposes. The cohesive property of gold is destroyed by moisture, but can be again restored by annealing.*

Tin foil, of which permanent fillings can be made, is composed of the pure metal. It is sent out by manufacturers in leaves of the same size as gold foil, and in thickness about the same as six-grain sheets of that metal. Pure tin, as just mentioned, can be welded in the cold state, but the union cannot be brought about unless the surfaces of the separate portions are bright and free from oxidation. This chemical change affects tin foil after a few hours' exposure to the atmosphere, and destroys to a great extent its cohesive property. This does not, however, much lessen its usefulness as a filling material. In plugging it is manipulated in the same way as non-adhesive gold foil.

Amalgam Fillings come next to gold and tin in point of durability. These are all formed by combination of mercury, either with a single metal or with an alloy of several. Perhaps one of the first of these compounds used in dentistry was that composed of coin silver and

* Within late years—as already mentioned—great advances have been made by manufacturers in preparation of gold for dental purposes. It is supplied ready for use in a variety of forms—cylinders, pellets and ribbons—and the operator is rarely obliged to undertake the preliminary manipulation which was formerly always called for.

mercury. The silver, reduced to filings, was rubbed up in a mortar with mercury, until a stiff pasty mass was formed, which became hard in the course of a few hours. This amalgam, although of considerable durability under favourable conditions in the mouth, had the disadvantages of becoming itself blackened by oxidation, and of gradually staining the tooth in which it was inserted. In spite of numerous attempts to do away with them, either or both of these imperfections, in a greater or less degree, are apt to occur with many of the amalgams since introduced; but in the better class of amalgams produced by manufacturers in late years, these disadvantages have been reduced to a minimum or entirely done away with. Most of these have as their basis silver alloyed with small quantities of tin, gold and platinum, the alloy being reduced to filings to facilitate union with mercury.

Palladium amalgam and copper amalgam, are each composed of pure metals with mercury. The palladium is manufactured for the purpose by precipitation, which produces a fine powder. Palladium amalgam does not stain the tooth, but its surface becomes intensely black. Undoubtedly, in any situation where its colour is of no moment, palladium amalgam is the best filling of its class we possess. Its expansion during setting is very considerable, and for this reason it must not be used when the supporting tooth walls are fragile. Palladium requires to be used quickly after mixing, as it sets with great rapidity; indeed, it is to this that it owes, to some extent, its superiority over other materials. Copper amalgam is supplied in the form of small solid pellets, masses of amalgamated copper and mercury. To prepare it for use, a sufficient quantity is placed in an iron spoon, and held over the flame of a spirit lamp, until globules of mercury appear on the

surface. It is then ground down in a mortar and forms a smooth paste, with an evident excess of mercury. It is then squeezed until much of the mercury having escaped, the mass assumes a drier and somewhat granular character.

Copper amalgam is one of the best filling materials for small crown cavities in temporary molars. In considering its use in the case of permanent teeth, it must not be forgotten that it tends to waste by chemical action, that it is most unreliable at the cervical margin, and that in the course of time, no matter how carefully worked, it does discolour the teeth badly, staining their texture throughout. The small shrinkage affecting copper amalgam may be diminished to a certain extent by using a mixture of old and new amalgam, and by working it as dry as is conveniently possible.

It was proved some years ago by the experiments of Mr. Charles Tomes that all the amalgams then in common use underwent contraction during the process of hardening, although the extent to which this occurred varied considerably in the different compounds, and in some it was so slight as to be insignificant. The amount of contraction was ascertained by obtaining the specific gravity of masses of amalgams when recently mixed and afterwards when hardened. In the former state, their density was found to be always less than in the latter, the difference being, of course, due to contraction. It is obvious that when the shrinking is more than infinitesimal in amount, a permeable space must be formed between the filling and wall of the cavity during hardening of the amalgam, and in such a case the stopping must necessarily fail to arrest decay.

The following table from Mr. Tomes' paper exhibits

a comparison of the weight gained (*i.e.*, shrinkage) by different amalgams while hardening :—

Palladium	·037
Sullivan's (copper)	·07
*Ash's	·14
*Smale's	·14
Tin and silver (55 to 45) . .	·35
Tin and silver (equal parts) .	·38

The compounds marked with an asterisk may be taken as fair specimens of the amalgams in ordinary use at the time these experiments were made. These experimental results accord in the main with those of practice.

Mr. Tomes' first observations were published twenty-five years ago. More recently* he has given an account of a series of experiments, which have cleared up many doubtful points regarding the physical peculiarities of amalgams.

Dr. Black has lately† published some observations upon the properties and behaviour of the silver-tin alloys, which include most, if not all, of the amalgams prepared by manufacturers; excepting only those already mentioned, viz., palladium and copper. Dr. Black's experiments are by far the most elaborate and exhaustive yet carried out, and they have gone a long way towards providing for the production on scientific lines of perfect amalgams for dental use.

He has found that amalgams when set, if put under pressure, as for example, a square block of amalgam upon which rests a heavy weight, in time alter in shape, the square block becoming pressed out of its rectangular form. This condition he calls the "flow." Subsequent investigations tend to show that another process which has been termed "ageing" has an influence upon

* Trans. Odont. Soc., 1895.
† Dental Cosmos, 1895 and 1896.

amalgams. It was noticed that specimens of alloys from the same ingot gave different shrinkage and expansion results according as they were freshly "cut"—reduced to filings—or mixed after some interval had elapsed after the cutting. By "fresh cut" Dr. Black means that "the alloy was used within one hour after cutting." The shrinkage of the fresh cut alloy is less than that of earlier cut.

Dr. Black's experiments are too lengthy to be fully described here, but a short summary of his results may be given.

Some of the alloys experimented upon appear to expand after having contracted, this of course being the reverse order to that generally accepted, viz., expansion followed by contraction. Experiments were made with what Dr. Black terms modified silver-tin amalgams, or those to which other metals such as gold, copper, zinc, &c., had been added.

The great factor causing "flow" in alloys seems to be temperature; oxidization, though formerly thought to play a great part, having apparently no effect. Heat (140°) caused cut alloys to shrink very quickly, and 130° caused the greatest amount of shrinkage. Changes in the working properties of amalgams are caused by heat and also by cold continued through a long period.

The practical outcome of these experiments was to point to the superiority of amalgams containing about sixty-five parts of silver and thirty-five parts of tin for unmodified amalgams; and silver sixty-one and three-quarters, tin thirty-three and one-quarter, and gold five, for modified alloys. Dr. Black's experiments have led to the more easy manufacture of quick-setting fillings.

All the alloys most recently prepared by various makers, are based upon Dr. Black's formulæ; and one or other of these will be found by far the most satisfactory

filling material where it is desired to employ amalgam. Alloys of this kind do not waste, they retain their colour, and do not stain the tooth, and above all are reliable at the cervical margin, the point of failure of so many of the old copper and silver-tin amalgam fillings. Dr. Black has, of course, published in the fullest detail the composition of the alloys he has found most to be relied upon; and stoppings made according to his formulæ are prepared by manufacturers. It is to some extent unfortunate that the composition of many amalgams in the market is kept secret by the manufacturers; although it is evidently impossible from the commercial point of view that the full formulæ and mode of preparation of these compounds could be published. There can, however, be very little secrecy as to the actual ingredients of the various amalgams, and the practitioner has to be satisfied with the fact which experience proves to him, viz., that modern amalgams supplied by leading makers are most admirable filling materials, and that instead of being put together merely by rule of thumb, they are compounded on the scientific principles laid down by those who have investigated the problems from the purely scientific side.

It must be borne in mind that an amalgam when hardened partakes more of the character of a chemical compound than of a mechanical mixture, and that although during the operation of filling one portion of amalgam may be used with more mercury than another, the mercury will be found equally diffused throughout the mass when the process of setting is at an end. It seems probable that the change in shape of the mass which sometimes occurs may be due to absorption of mercury from those portions where it is in excess—often the outer portions—into those parts which contain less mercury. In theory it would appear that

even the extremely minute contraction or change of shape, which accompanies the hardening of most amalgams, minute though it be, must be alone an insuperable objection to their use for fillings; but practically, well-chosen amalgams manipulated with due skill and care endure for an indefinite period.

Many points with regard to the properties of amalgams are still undecided. Among them the question as to the proportion of mercury which it is best to use with the different compounds is still an open one, the balance of evidence being, however, in favour of the admixture of a quantity no greater than will suffice to produce a plastic mass, which becomes coherent under slight pressure.*

In addition to staining the tissue, some amalgams have the effect of rendering the surface of dentine against which they rest extremely hard. This appears due to saturation of the tissue to some slight depth by the metallic salts set free during oxidation of the amalgam. In the case of copper amalgam the tissue in time becomes so hard as to resist effectually the further inroads of caries, and this effect doubtless has a share in increasing the permanence of this amalgam as a filling, counterbalancing the effect of the slight contraction which it undergoes whilst hardening.

Gutta Percha.—Among filling materials of a more perishable nature than the metallic compounds just described, to gutta-percha may be assigned the first place; indeed, although its physical character renders it unfit to sustain the wear of mastication, its durability as a filling in proper situations is very great. For dental purposes gutta-percha is prepared in the form known as Jacobs' and Hill's stoppings. These consist

* In mixing amalgams, the actual composition of which is secret, the practitioner must, of course, be guided mainly by the manufacturers' directions.

of gutta-percha, bleached and intimately blended with silica, or some like substance, in the form of an impalpable powder, to render the material harder and more durable.

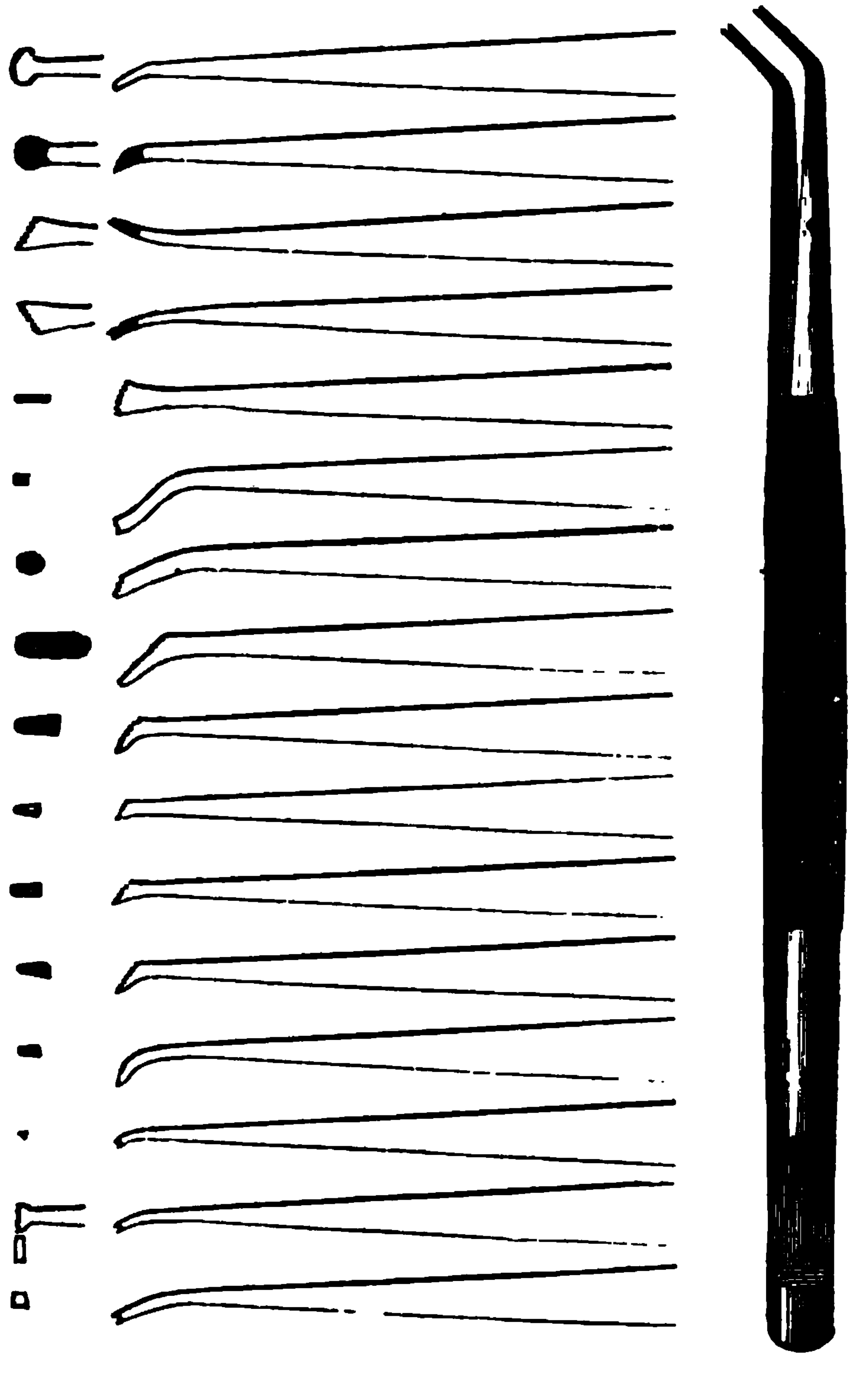
Plastic Cements.—There has been introduced during late years a numerous class of useful compounds for fillings, to which various fanciful names have been given by manufacturers. Some of these are mainly composed of oxide of zinc mixed either with silica or marl. This pulverulent mixture, when required for use, is worked into a paste, with a strong solution of zinc chloride. Chemical combination takes place, and a hard mass is rapidly formed, consisting of oxychloride of zinc, with the earthy ingredients mechanically mixed. These latter serve to impart greater hardness to the filling. Chloride of zinc being extremely irritating, this filling must not be used where the pulp is nearly exposed. Similar cements, of which the main ingredient is phosphate of zinc, and which are both non-irritating and more durable than the oxychloride compounds, are now supplied by manufacturers.* In the manufacture of cements, as of amalgams, very great improvements have been brought about in late years; and compounds, perfectly free from irritating properties, and much more durable than earlier products, are now available. The exact composition of these materials is usually secret, although many of them are produced by manufacturers in whom the profession have, with reason, great confidence.

Temporary Plugs.—For the purpose of sealing up cavities in the teeth for a few hours or days, to cover a dressing, to subserve the purpose of pressing away a mass of swollen gum, and for similar objects, absorbent

* In future pages the term "cement is used to denote this last class of compounds.

cotton wool, saturated with a solution of gum mastic in spirit, or of gutta-percha in chloroform, may be used. After the insertion of the pellet the fluid evaporates, leaving a tough mass impervious to moisture. These

FIG. 184.



pellets are apt to cause a disagreeable taste, and form a source of discomfort to sensitive patients, so that the soft, highly-plastic gutta-percha, now specially manufactured for temporary stoppings, is, as a rule, to be preferred.

Instruments used in Filling Teeth. — A pair of plugging tweezers, a set of eighteen pluggers (Butler's pattern, fig. 184), and a mallet, will be found sufficient in filling the majority of cavities with gold. The tweezers, the blades of which when closed form a plugging point, are for the purpose of carrying portions of stopping into the cavity and fixing them there prior to consolidation. Of the pluggers seven or eight will have serrated wedge-shaped points, of various sizes, and bent at different angles convenient for reaching cavities wherever situated. These are used for carrying gold into position and in packing or welding it there. Foot-pluggers of different patterns will be included in the set. These serve to consolidate the component parts of the plug. In addition, there will be four or five instruments with working extremities flat faced and serrated, and so bent or twisted on the shaft as to reach cavities to which straight foot-pluggers could not be applied. Lastly, there will be provided a burnisher, having a rounded, highly-polished steel point. The same set of instruments serve in filling with tin foil.

In the construction of cohesive and non-cohesive gold fillings, the consolidation and the welding of the metal is much facilitated by the aid of the mallet, an instrument which has come into general use in late years. A quick succession of sharp blows, carefully regulated, and given by a mallet of proper weight, does not inflict more pain upon the patient than the pressure of the hand alone, whilst the effect is to weld and condense the foil more rapidly and thoroughly. The heads of hand-mallets which are manufactured for this purpose, are made of lead, or some such soft metal, and weigh about two ounces. In order to facilitate the use of the mallet, and to leave one hand of the operator free, automatic instruments are now constructed, to which a series of plugging

points of various sizes and shapes can be adjusted as required. Some mallets are made to work with the dental engine, others to act by electricity. With these instruments the amount of force may be regulated with the utmost nicety to meet the exigencies of particular cases.

A set of instruments (six or eight) with smooth round steel points are most suitable for packing amalgams. If the points which are used with these materials be serrated, the rough surface soon becomes clogged with amalgam, which lodges and hardens there, forming a layer, which, softened again by the mercury, is apt to mingle with an amalgam of another kind on a subsequent occasion.

A set of small spatulas are required for the insertion of oxychloride of zinc cement, and the blades of these may be advantageously made of silver or platinum, steel being rapidly oxydized and destroyed by these fillings. A similar set, with smooth steel blades, will suffice in packing phosphate cements; and a variety of spatulas and pluggers are provided for gutta-percha, and the insertion of temporary plugs of cotton wool and cement.

Filling with Gold.—It has been already explained that two varieties of gold—non-cohesive and cohesive—are used in filling teeth, and that their difference consists in the fact that fragments of the former kind do not cohere when pressed together, whereas separate portions of the latter may be welded and united into a solid mass. Plugs of non-cohesive gold must be formed always by the wedging together of folds or layers of foil; whilst on the other hand, in fillings composed of cohesive gold, the mode of arrangement of the successive portions is of little importance, provided they be made to unite with each other. Although portions of non-cohesive foil do not actually coalesce under pressure, they become

sufficiently dense to take a high polish, to resist mastication perfectly, and to constitute a stopping absolutely impermeable to moisture. Indeed it is much easier to make a water-tight plug of non-cohesive than of cohesive gold. A cohesive gold plug can be perfectly built up only when it is composed of small pieces slowly and thoroughly welded together. If an attempt be made to consolidate a great mass of cohesive foil it condenses on the surface beneath the instrument, but no amount of force which can be safely applied to a tooth is sufficient afterwards to affect the deeper portions which therefore remain imperfectly united and porous. The presence even of a trace of moisture, such as is liable to be deposited on the surface of the gold from the breath of the patient during the operation also prevents perfect welding from being accomplished.

In using cohesive foil it is very often possible to get the advantage of wedging, as well as cohesion; and, indeed, this is mostly aimed at partly or throughout the structure of cohesive plugs. Cohesive cylinders or folded tapes of foil, packed endwise and compressed, can be united into a solid mass with much less labour in welding than is needed with loosely-rolled pellets. The advantage of cohesion in foil is perhaps best seen in cases where the gold has to be carried against a fragile wall—as in a badly decayed incisor. An attempt to wedge a mass of gold in such a situation would probably completely break down the wall. With cohesive foil, in such a case, it is merely a question of time and patience to build up from a solid foundation a stopping, or wall or buttress composed of small shred after shred of foil slowly worked upon the rough surface of the growing plug.

Either variety of gold, cohesive or non-cohesive foil or sponge, can be used exclusively in almost any cavity,

but the properties of non-cohesive foil make it most useful in simple cavities—i.e., those of the form of a hole or trench with vertical or nearly vertical walls—whilst the peculiar qualities of cohesive gold render it invaluable in irregular, difficult cavities, and where a plug has to be built up from a limited foundation. It is in many cases good practice to combine two kinds of foil, commencing with non-cohesive and using cohesive to build up the plug, or to key together securely the separate portions.

If the cavity be small in size and simple in form, the following method may be adopted. A sufficient quantity of non-cohesive foil—four to six grain sheets—is folded lengthwise by means of a spatula into narrow ribbons, each containing a third or a quarter of a sheet. These ribbons are next cut into short strips, which may be conveniently spread upon a wooden tray covered with smooth woollen cloth. The point of a wedge-shaped plugger is next pressed upon a few of the strips one after the other, which are thus fixed lightly to the instrument. The gold is thus carried into the tooth and lodged, so that one extremity of the folds rests on the floor of the cavity, and the other protrudes from the orifice. Plugging forceps may be used to carry in the gold and lightly fix it in position. Portion after portion of gold is inserted in the same way, and forced against the walls of the cavity until it becomes difficult to make the instrument enter. A smaller point is then used, and this is forced into the centre of the filling, the hole so formed being again filled with strips.

The surface of the filling is next compressed by a broad, followed by a small, pointed instrument. Finally it is filed smooth, and then polished by means of slate stone and water, followed by a burnisher. The whole process of reducing, shaping, and finishing, is best

carried out with a succession of burrs and wheels followed by polishing discs used with the dental engine.

The surface of gold fillings should be left convex in shape, and slightly above the level of the surrounding tooth, unless the projection interfere with the bite. They should not, as a rule, overlap the margin of the cavity.

The procedure just described may be varied by the use of cohesive gold towards the end of the operation to fill the holes made by the perforating instrument. Again the entire cavity can be filled with cohesive gold.

FIG. 185.

A loosely folded ball or pellet, or better a series of unannealed cylinders are packed on the floor of the cavity, and consolidated, and to this are one by one added annealed highly cohesive cylinders, each being thoroughly welded or kneaded to the mass by means of small pointed serrated instruments. Cohesive gold in the form of foil may be prepared for use in strips similar to those of non-cohesive foil, just described, and like them may be carried into position on the point of a plugger; or portions of foil or cylinders may be fixed by the plugging tweezers, and afterwards condensed by other instruments, assisted on occasion by the mallet.

Large cavities of simple form may be most rapidly and effectually plugged with cylinders or rolls of non-cohesive foil. The cylinders of cohesive and non-cohesive foil are to be obtained of the foil makers in great variety of sizes, and of the most exquisite plasticity, and this does away with the necessity of the operator preparing foil for use. They may, however, be prepared by the operator. They are formed by winding a ribbon of foil round the point of a thin broach. They should be of such a size that many are required to fill the cavity, and

FIG. 186.

of such a depth that when inserted endwise they project slightly from the orifice. Those used to commence the plug should be loosely rolled, so as to be soft and malleable, but those for the latter part of the operation may advantageously be rolled more solidly or compressed slightly before insertion. In commencing the filling, one of the cylinders is carried by the plugging forceps into the cavity, and gradually condensed against one of the walls by foot-pluggers. Another and another are then introduced in the same way, each one being thoroughly consolidated before another is inserted, until the cavity is nearly full.

The cylinders should be packed all round the outer margin of the cavity, so that the plugging instruments need not be forced actually against the wall of enamel with the risk of injuring it. A wedge-shaped instrument is then gradually worked in between the last inserted cylinders, and these are consolidated by foot-pluggers. There then remains a small hole to be filled. This may be done with strips of non-cohesive ribbon, or with fragments of cohesive foil. The rest of the surface may be next tested by a sharp-pointed plugger, and at any point at which it may be made to enter gold is added. The surface of the plug is finally filed down and polished.

The operation of filling with cylinders is illustrated in figs. 185, 186, 187. In the first of these the commencement of the filling is seen, two soft cylinders having been placed in position by the plugging forceps ready for consolidation, by the foot-plugger, against the wall of the cavity. The next diagram, fig. 186, shows a later stage of the operation, but the cylinders, in order to show the structure of the plug, are depicted insufficiently consolidated. By the time the stopping had approached this stage the cylinders would all have been thoroughly consolidated by pressure of foot-pluggers worked over their lateral surfaces from the depths of the cavity outwards.

As soon as the walls have been lined with plastic cylinders, and these consolidated, the rest of the filling may be composed of more compressed cylinders, to save to some extent the work of consolidation within the cavity.

The filling now approaches completion, and a small central space alone remains to be plugged with strips of non-adhesive or fragments of adhesive foil. Fig. 187 exhibits this latter process in operation, and it also shows the extent to which a plug should project from

the cavity before the surface is finally consolidated, filed smooth, and polished.

A filling built up in this fashion, carefully consolidated, cylinder against cylinder, and wedged finally with a small plug of cohesive or non-cohesive strips, will present a very dense impermeable surface. These represent the "old-fashioned" soft gold stoppings, specimens of which the handiwork of the older school—the school which practised before the common use of cohesive foils—are even now sometimes met with after a lifetime of use in the teeth of very old patients. For durability no stoppings with gold can surpass those

FIG. 187.

properly constructed on this method; nor in practised hands can any method be carried out so rapidly.

Fig. 188 shows a mode of beginning a filling with non-adhesive foil in a cavity of the trench-like form already described, and illustrated in figs. 163 and 164. The filling is commenced by fixing a mass of gold in the upper and lower extremity of the cavity. These masses may be composed of strips or small cylinders, and are so packed that they project slightly from the mouth of the cavity. The filling is completed by packing between these buttresses successive portions of foil in strips, in the manner described in speaking of small, simple cavities.

If cohesive foil be used, either partly or entirely, the filling may be commenced in the same way, or a loosely rolled pellet or cylinder may be packed on to the floor of the cavity, and the plug completed by welding to the first securely-fixed masses, portion after portion of foil in the form of cylinders, or strips, or pieces of loosely rolled ropes of foil.

In cases in which cohesive gold is to compose the whole or the greater bulk of the filling, the first and most important step consists in fixing portions of gold securely in the cavity. Upon these portions, more and more foil, in the form of strips or cylinders, is welded until the cavity is filled with a solid plug. In many

FIG. 188.

instances the shape of the cavity after excavation allows of the secure formation of the foundation of the filling, or affords suitable positions for the packing of retaining points without further preparation, and the filling is commenced with strips, pellets, or cylinders. In some cases small pits, or retaining points of the kind already described must be cut, into which the gold being packed, the completed filling becomes dovetailed immovably in position.

Fig. 189 shows the commencement of a filling in the cavity already illustrated in figs. 165 and 166, three portions of gold being fixed in the retaining points there displayed. Each of these pits or points has been separately dealt with as a simple cavity, and packed

with small cylinders or strips, each mass of gold projecting beyond the orifice of the main cavity. This part of the operation being accomplished, the construction of a plug on one of the methods already

FIG. 189.

described presents no difficulty. The same principles are applied to the filling of more complicated cavities in which retaining points are necessary, or in cases in which a plug has to be built up from a limited foundation. The first thing to be done is to form the points of support, anchorage, or foundation, care being taken

FIG. 190.

that the masses of gold extend into the main cavity or project beyond its orifice when a filling on the wedging system is to be inserted.

Anchorage for a filling may often be most effectually obtained in a foundation of cement. Illustration of one

example may serve to suggest the utility of this expedient in many cases. The filling of the cavity depicted in fig. 162, is shown, in section, in fig. 190. The deeper part of the cavity has been laid in with cement; and before this has hardened, cylinders of foil have been fixed endwise in it. To build up from this foundation a filling of cohesive foil is a simple operation.

A cavity of the character shown in fig. 168 may be filled with cohesive gold, used in the form of tape, folded to a suitable width and thickness. A sheet of No. 4 foil folded four times would make a suitable thickness, and it should be cut into strips of such width that when used they do not obscure the view of the cavity. Finer strips should also be cut for filling the retaining points.

The retaining points, each treated as a simple cavity, should be first filled and then connected together by a bridge of gold, formed by welding together successive fragments, strips, or cylinders of cohesive foil. This will secure a firm foundation for the plug, on to which the gold can be packed layer by layer. Care must be taken that the grooves are filled with well-condensed gold, and that the foil is well and carefully packed over the outside edges of the cavity. In every cavity it is essential for success that each layer as a whole, and each added component part of every layer, be well condensed before another is built upon it.

Fig. 191 illustrates another method of filling a cavity of this nature, specially applicable to cases where the decay extends to or below the gum.

A matrix having been fitted to the tooth, a layer of non-cohesive closely rolled gold cylinders is packed at the bottom of the cavity, with their ends slightly projecting, and condensed. On this layer another is packed, and so on until the cavity is nearly half full. With a sharp instrument retaining points should then be

formed in the gold along the line of the grooves marked G in fig. 169. These points should then be filled and bridged together by means of thin strips of cohesive gold and the remainder of the plug built up as described in the preceding paragraphs.

It is, of course, apparent that when filling a cavity in this manner the retaining points marked P P in figs. 168 and 169 are not required. It is a good plan before placing the non-cohesive cylinders in position to slightly flatten them, so that more can be packed in a row and they can be the more easily condensed.

FIG. 191.

Formation of a plug along the cervical margin of all cavities is part of the operation of stopping which calls for the greatest care, and at the same time tests most the skill of the operator. If the filling be not perfectly constructed along the line of and below the gum, decay is certain to recur at this point, sooner or later. A minute fissure, or a slightly rough surface, at some point constantly swept by the tongue, or rubbed during mastication, may not materially affect the durability of a stopping; but between the necks of teeth, where foreign

particles must constantly lodge, caries is certain to be set up along an imperfect line of junction of stopping and tooth. The operator dealing with the cervical edge will display his skill, not only in perfect consolidation of the stopping, but in leaving it at the right external level, so that the minimum of filing may be needed in the finishing process. The use of the file at the neck of the tooth is always a painful process.

The strength (durability) of any stopping is in most cases only equal to that of its weakest portion; but the recurrence of decay owing to slight imperfection in a plug, is much more likely to speedily ensue in positions such as exemplified in this case, along the line or below the level of the gum. Unless the most exquisite nicety both in packing and finishing be maintained in this part of the filling, the labour bestowed on the rest of the plug will be mostly thrown away.

In dealing with a cavity such as shown in figs. 170, 171 and 172 the retaining points should first be filled, then the connecting grooves. This can be done with cohesive strips, and upon the foundation so formed a mass may be built up to the level of the surrounding walls and gradually carried over the cut margins of enamel and dentine until these are covered. The contour of the tooth may then be gradually restored by the welding on of more and more foil. Section of the tooth through the completed filling — A A indicating retaining points, U U the groove—is shown in fig. 194.

In all cases each retaining point and groove must be first treated as a separate stopping, the gold being thoroughly consolidated and the plug left projecting, when necessary, into the main cavity to a sufficient extent, so as to form a foundation, a wall, or buttress, upon and against which the mass of stopping can be built up. The importance of this part of the operation

cannot be too strongly insisted upon; unless it be perfectly carried out a durable stopping cannot be constructed.

The drawing in fig. 192 is an attempt to depict the operation in progress. A solid mass of gold built up from the groove and retaining points (indicated in figs. 171 and 172, and shown, in section, in fig. 194), occupies the upper part of the cavity, and forms a foundation upon which fragment after fragment of cohesive foil can be welded. These

FIG. 192. FIG. 193.

fragments of foil are used smaller and smaller as the fragile margins of enamel are approached. Where a wall of enamel alone remains, which in a front tooth it is important to preserve for appearance, the exquisite plastic qualities of cohesive foil enable an operator having the necessary tactile skill, to mould against the wall and over its external margin a supporting and protecting buttress. This can be done with no other permanent filling material. Fig. 193 shows the stopping completed. The degree to which the original form of

the tooth is built up in these cases must be governed by the amount of strain the filling is likely to encounter, and this again will largely depend upon the bite. Many patients will prefer to have a front tooth left bevelled off to a large extent, rather than endure the disfigurement of a large gold stopping, and as the bevelling must add to the stability of the stopping, this feeling can always be deferred to. It is, however, often better to leave a line of gold visible on the labial aspect than to bevel it flush with the enamel edge. The gold behind the edge

FIG. 194.

sometimes causes refraction of light, and gives an appearance of opacity or discoloration simulating decay.

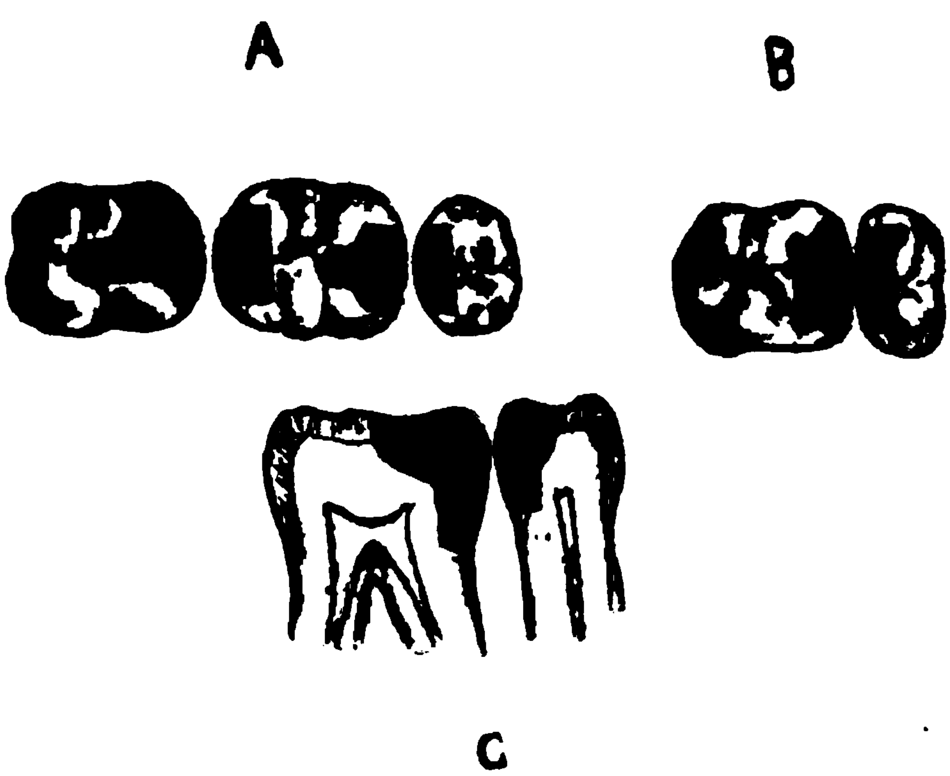
Examination of fig. 194 will show that the weakest part of the plug is where the outside unsupported portion of the contour joins the portion wedged into the tooth. This is where the line of fracture through the enamel generally runs when an accident happens; to avoid this the operator must be particularly careful that the gold is put on in thin layers and that condensation is perfect.

Contour Filling.—The operation of restoring the contour of teeth has already been introduced and partly

discussed in various places in preceding paragraphs. Cases differ so much in minute details, owing to the ever-varying shape of individual teeth and their relation to neighbouring and opposing teeth, that it is impossible to prescribe rules of more than general applicability to cases where contour filling is attempted. The chief object of this form of filling is to restore the full power of mastication, and to prevent lodgment of food in interspaces. The surfaces of the fillings which articulate with opposing teeth must be formed to correspond with the cusps that impinge upon them; and, if possible, should be so moulded that the movements of mastication may not tend to force food between the teeth. The rest of the contour should be as rounded as possible; and the point of contact with the adjacent tooth should be limited, so that a wide area of the approximal surfaces is not in close contact. Surfaces of stopping alone should touch each other; and, indeed, in all but rare cases, the enamel walls, in preparing the cavity, will have been cut back so far as to ensure this. Approximal surfaces should be, of course, finely polished, and when in apposition should, where touching, be not so tightly impacted as to prevent passage of a thin quill tooth pick or a strand of floss-silk. The rest of the surfaces should be so far as possible shaped to allow of their being swept by the tongue, and cleansed by the tooth brush. Two sittings at least will be needed, as a rule, after preparation of contiguous cavities for contour fillings. One cavity will be first filled and finished with the exception of final polishing. A temporary stopping will keep the teeth apart, and the wedge or matrix will maintain the separation during filling of the second cavity. When finished the approximal surfaces will in a few hours fall into contact on removal of the pressure; and where doubt exists they must be again examined

and reduced if too tightly impacted. The drawings of molars and bicuspids marked A in fig. 195, exhibit the crown view of well made contour stoppings ; and these are shown in section at C in the same illustration. The fillings should be in contact at the points where they approach each other in the cuts ; it would be of course impossible to define them in the drawings without spaces. The stoppings shown at B illustrate faulty construction. The narrow long line between the teeth

FIG. 195.



would form a trap for food particles which would be with difficulty cleared away. In the drawing A, the molar crown stoppings incidentally show cut out fissures filled, and forming retaining "steps"; and the advantage of these (referred to in earlier paragraphs) in securing the stopping by distributing the strain during mastication will probably appear obvious.

Filling with Tin Foil.—This material is manipulated and packed in precisely the same way as non-cohesive gold foil.

Filling with Amalgams.—The most favourable cases for amalgam fillings are those in which the general structure of the teeth is of good quality; the most favourable cavities such as are situated on the grinding surfaces of the teeth, or in situations where they are constantly subject to friction by the tongue or in mastication. The durability of amalgam filling largely depends upon the amount of care which is bestowed on the preparation of the cavity. It must be borne in mind that amalgam does not adhere to the walls of a cavity, but is held as a plug by packing alone. It must, therefore, be thoroughly supported by solid walls, and fixed in position by well-planned retaining points where needful. Amalgam does not answer well packed over a chamfered or bevelled edge, and therefore this shape should not be given to the inner margins of the orifice of a cavity where these materials are used. Too much care cannot be taken in finishing the orifice of the cavity, and by means of corundum points and the burring engine in rendering the inner margins of suitable form and perfectly smooth. Many of the remarks which have been made with regard to gold apply equally to amalgams. They should never be inserted in a mass, but should be thoroughly packed piece after piece, and retaining pits should be freely used on shallow sloping surfaces. Each retaining pit or groove should be packed with amalgam with the utmost care. If a great mass of the stopping be inserted at once and the whole forced home, it will mostly happen that retaining pits will receive only the mercury which exudes under the pressure. But when the stopping sets the expressed mercury at the surface will be absorbed into the amalgam, and the pits will be left, if not empty, at least imperfectly filled. It is important in packing to obtain absolute contact of the

amalgam with the walls of the cavity, and to prevent a layer of mercury (which is often squeezed from the mass) from remaining around the forming plug. To achieve these objects it is first necessary to render the cavity absolutely free from moisture, and to keep it so throughout the operation. If the cavity throughout be surrounded with strong walls, or if a matrix be applied, and the dentine not highly sensitive, the amalgam may be used without excess of mercury—in a condition in which pressure is needed to consolidate it; and considerable force may be exercised in packing the stopping. It is, however, often a very good plan to begin the stopping with amalgam soft through excess of mercury, and to express the surplus quantity in packing. This plan is especially useful where sensitive dentine is present, and particularly with patients who do not bear pain well—for example, in treating temporary teeth and first permanent molars in childhood. With this plan the first portions of soft amalgam are gently smeared over the floor and walls of the cavity. Then some folds of bibulous paper are carried in and the pluggers worked over this with gradually increasing pressure.

The globules of mercury as they exude are swept out of the cavity and away (over the rubber dam or napkin) by the paper held in the plugging forceps; and the same procedure is repeated until the cavity is full; amalgam towards the last being used with less mercury. With copper amalgam particularly, and in children's teeth it will be found that a pellet of cotton wool answers better than paper. It is not perhaps so effectual in forcing out mercury, but it gets rid of enough, and it makes the operation either painless or much less painful than with use of an uncovered steel plugger. Cotton has no great tendency to adhere to the amalgam—hardly more than paper; and a few occasional adherent filaments are

easily scraped away before a new portion of amalgam is added. With some amalgams it is recommended that besides driving out mercury in this way by force, tin foil should be applied at intervals to take up mercury from the surface of the stopping; and this procedure seems to render the amalgam harder and more perfect as a filling. It must, of course, be understood that the working of amalgams supplied by manufacturers must be used—as a rule—in accordance with the directions accompanying them.

The time occupied in hardening varies very much with the different compounds—some are quick, others slow setting. Palladium sets during manipulation, and needs to be rapidly packed as soon as mixed. Other amalgams occupy only a few minutes, but most take several hours to become thoroughly hard. Amalgam stoppings must therefore be shaped so as not to be injured whilst soft on closure of the teeth, and they must not be used in mastication until thoroughly hardened.

After amalgam has hardened it is of the utmost importance to file it level with the margins of the cavity, and to polish it. If this precaution be neglected, overlapping portions of the filling in time break away and leave around a rough surface, which favours the adhesion of decomposing particles, and soon becomes the seat of carious action.

In proportion to their bulk and to the nearness with which they approach the pulp, metallic fillings—whether of gold, tin or amalgam—being rapid conductors of heat, necessarily increase the susceptibility of teeth to changes of temperature. The increased susceptibility is as a rule most marked in teeth of delicate structure; and it is of course greatest in those cases in which

prolongations of the pulp cavity run abnormally close to the surface. In favourable cases the sensibility usually passes off with the lapse of time. In such cases a current of cold air, or contact with cold or warm liquids, excites a bearable sensation in the tooth, which slowly subsides within a few moments. In unfavourable cases the pain continues for minutes or hours; and if the frequent irritation of the pulp, to which the pain is due, be allowed to go on it may pass into acute inflammation. To avert such an untoward event it is a good rule of practice, a rule which ought indeed to be invariable, to cover the depths of large cavities, or such as show uncommon sensibility, with a layer of non-conducting filling. A very thin layer suffices; and the plastic cements, are best for the purpose. Tin foil, which is a worse conductor than gold, may in some cases be well used as a foundation for large fillings of that metal.

Filling with Cements and Gutta Percha.—Preparation of cavities for plastic cements (the zinc compounds described) and for gutta percha, does not in any essential respect differ from what is necessary with other materials; but the cements do not usually require retaining points, whilst gutta percha will rarely answer in any cavity where small retaining points are needed. The cements attach themselves with considerable tenacity to any surface which is rough and perfectly free from moisture; they are the only fillings which can be securely fixed by mere adhesion to the walls of the cavity; they form perfectly water-tight stoppings, and are non-conductors of heat, and were it not for their perishable nature would, perhaps, constitute more perfect substitutes for the lost dental tissues than any other substance at present available.

Neither cements nor gutta percha answer well over chamfered external margins; they need enclosing within

straight walls, particularly at the neck and cutting edges of the teeth. Cements and gutta percha require the exercise of such slight force in filling that they can be inserted in front teeth without sacrifice of thin enamel, against which it would be impossible to pack a metal stopping.

Cement stoppings are liable to waste at the surface, and the waste in many cases is due to slow solution, not to attrition. The waste from this cause varies very much in different mouths, no doubt in accordance with the conditions of the secretions. Neither these cements nor gutta percha are, however, fitted to long withstand the wear of mastication. Cements do not last well in situations where they are not constantly swept by the tongue, or otherwise guarded from prolonged contact with decomposing particles of food; in such situations gutta percha is much more durable.

In using gutta percha, pellets are softened on a metal tray over the flame of a spirit lamp, or by rapidly passing them to and fro over the flame, and packed into the cavity by means of heated instruments, great care being taken, while making the mass sufficiently soft, not to injure its texture by overheating or burning it.

In cavities not easily accessible, it is desirable not to add excess of this stopping, as it is difficult and tedious afterwards to cut away superfluous portions. Any slight excess can be easily removed, and the surface rendered smooth by wiping with a pellet of cotton wet with chloroform in which gutta percha is soluble. A small spatula having a thin fold of cotton round the end is useful to swab in this way surfaces between the teeth. External margins of a cavity which need it must be polished before insertion of gutta percha fillings. Cements do not last well at or below the level of the gum, and in a large number of cases it is good practice

to fill the cavity at that part with gutta percha and complete the filling with cement.

Porcelain Inlays. — Rapid evolution in methods of inlaying with porcelain has gone on in late years. At first the process was mainly restricted to large cavities in front teeth. Fragments of artificial porcelain teeth were used. These were ground to fit the cavity as accurately as possible and cemented into place. Sometimes they were more effectually secured by soldering small gold wires to the platinum pins of the fragment of artificial tooth; the metal attachments being carried into convenient angles of the cavity and fixed there by cement or stopping.

In the course of time several improvements in the older methods were introduced. Shaped rods, bars, or discs of porcelain, varying in size and colour to meet the requirements of different cases, were provided by manufacturers. The method employed in their use was in all cases practically the same. Special burrs, worked by the dental engine, shaped the cavity into which it was desired to fix the inlay. A rod or disc of porcelain, corresponding to the special burr, was then selected, a section of which fitted accurately the cavity. Tapered rods could thus be fitted to interstitial cavities in front teeth, or discs to cavities in labial surfaces. This method remains still perhaps the best for a class of easily accessible small cavities. A more satisfactory operation for larger and irregularly shaped cavities was devised more recently. This consisted in taking an impression of the cavity in platinum foil, investing it as in gold soldering, and fusing in a furnace a porcelain body to form an inlay actually moulded to the cavity. Dr. Jenkins, of Dresden, has within the last few years elaborated a modification of the above method, which whilst calling for care and skill,

is capable of producing results which could not be achieved by older methods. In this method the cavity —be it what it may—is excavated and shaped to the desired dimensions, in exactly the same way as would be done were the tooth about to be filled with gold, with this difference, that no undercuts are at first made, and the walls are formed with straight plane surfaces, to facilitate withdrawal of the mould. In many instances it is best to reduce the cavity to uniform concavity—somewhat of a saucer shape. A piece of gold foil (No. 30 or 40), slightly larger than the cavity, so as to cover all the walls, is then pressed into the cavity with small pellets of amadou until a perfect model results. This after careful removal is invested in asbestos in a platinum spoon. An enâmel body, of Dr. Jenkins' special preparation, of similar colour to the natural tooth operated upon, is then chosen. A small quantity is placed in the gold mould, and fired in a small muffle furnace. This operation is repeated until a porcelain inlay is formed, exactly adapted in shape, size and contour to the cavity for which it is intended. The gold foil is then removed, the inner circumference of the inlay grooved with a diamond disc, and the walls of the cavity having been slightly undercut, the inlay is fixed in position by cement.

With deep irregular cavities, it is best to fill them first to a sufficient extent with cement, leaving either a smooth flat or a concave surface on which the inlay may rest.

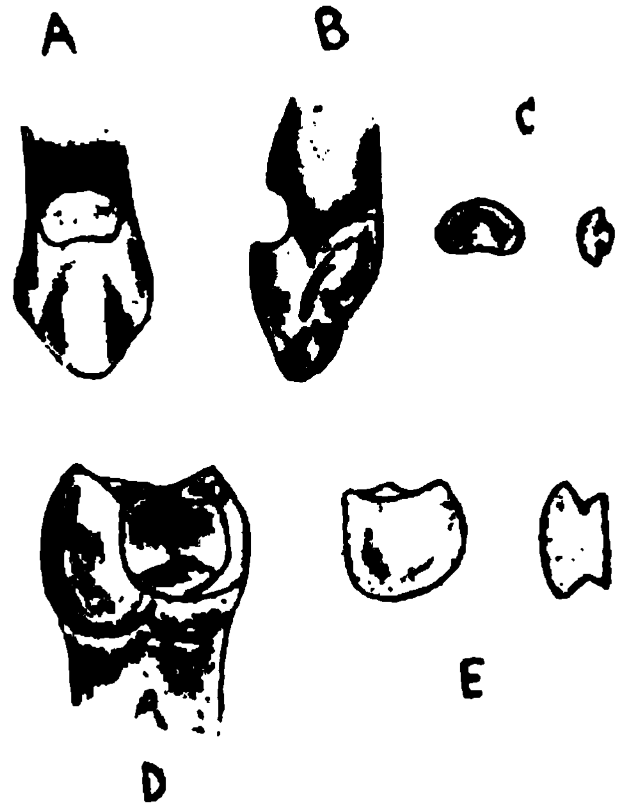
In interstitial positions space for withdrawal of the mould must be made by pressing apart the teeth and chamfering the surfaces. The thickness of the inlays will vary with the character of the cavity; they need always to be thick enough to form a solid filling, but can be used much slighter in approximal cavities in front teeth

than where they are subjected to strain of mastication. Interstitial cavities can, therefore, often be safely reduced in depth by a foundation of cement, proportionately thicker than might be needed in cavities elsewhere. This method permitting as it does of gold foil being used in place of the harsher and consequently less readily manipulated platinum, places within reach a means of easily making a perfect mould of the cavity, and restoring the appearance and usefulness of teeth, which, formerly, could only be laboriously filled with huge and unsightly gold stoppings.* Practice enables an operator to construct inlays which fit the cavity with exquisite nicety; so that when fixed finally there exists barely more than a microscopical film of cement, forming the external joint. Practice can be obtained first on extracted teeth; and the process may then be begun in simple cases in the mouth. In finishing the joint too much care cannot be exercised. The cement having hardened and superfluous fragments being cleared away, the surface should be tested with a needle-pointed steel probe, and at any spot where roughness is detected fine polishing should be carried out. The process of inlaying by Dr. Jenkins' method is best divided into two parts. At the first visit the cavity can be excavated and shaped, a foundation of cement put in, and a mould taken. The patient being dismissed with a temporary stopping in the cavity, the inlay may be made in his absence, and fitted into place and finished on a subsequent visit. Inlays skilfully made and inserted by this method will almost defy detection, and it is hardly too much to say that the skill of the operator is the only

* It seems unnecessary to enter further into the minute details of this process of inlaying, since these are explained in the instructions accompanying the special apparatus with which the practitioner, who wishes to work the process, must provide himself.

limit to the scope of their applicability. This method has been tested sufficiently to establish its durability. Theoretically, it might be supposed that early failure of the inlays must be expected in consequence of destruction of the cement joints; but the minuteness of the joint seems to do away with this danger entirely, and well made inlays exhibit no appreciable signs of failure after years. There seems no reason why an inlay which has

FIG. 196.



in this way stood for a few years, should not endure for many more. It is within the experience of practitioners who have practised inlaying extensively, that many disc inlays put in before the moulding method was invented, show no sign of failure after from five to ten years of wear.

In fig. 196 an attempt is made to illustrate the subject, so far as may be possible. A and B show front and side views of a cavity in and below the neck of an upper canine; and a front and section view of the

inlay is shown at C; the latter view exhibiting the undercut posterior groove. A typical cavity in a bicuspid is shown at D; and at E is seen in front and in section the inlay to restore the contour of the tooth with which it is to be filled. Both cavities are in form for mould-taking, the walls have not yet been undercut to retain the cement.

With regard to choice of materials in cases ready for the reception of permanent fillings, some few remarks seem called for. Where the walls are strong enough to bear the force of packing there occur few cavities in which the insertion of a gold plug is impossible, and regarding the question from a *merely theoretical* point of view, it might be plausibly urged that the instances are rare in which use of any other material as a stopping intended to be permanent is justifiable. The exquisite plasticity of gold and the perfect fashion in which a plug of this material, or a contour filling can be built up from a limited foundation; the facility with which it can in skilled hands be worked along fragile walls, and even carried over their external thin margins to give them support; and the artistic beauty of the completed work render the operation of gold filling a pleasant task to the accomplished operator. Practically, however, it is often not only justifiable, but necessary or expedient to employ other substances. In the first place the expense of gold-fillings puts them beyond the reach of the lower and of the poorest classes. Not only is the material more costly, but the expenditure of time and arduous labour far exceeds what is called for with other materials. Then again very few patients will subscribe to the opinion that a large gold filling conspicuously visible at

the front of the mouth has any artistic or æsthetic qualities. In the next place, the operation of gold filling in large and difficult cavities is long, tedious, and frequently painful, and there are many patients who either cannot or will not submit to it. All being in readiness for the commencement of the operation—cavity prepared and saliva excluded—it is hardly possible construction of the largest and most elaborate amalgam filling—not including finishing and polishing—could occupy more than half an hour; such a case would require hours of close application if gold were used. Restlessness on the part of a patient adds much to the difficulties, and no doubt conduces often to failure under the hands even of the most skilful. A perfectly constructed amalgam or even cement stopping in a proper case must be better than an ill-consolidated one of gold, which although perhaps appearing solid on the surface, may yet allow of slow percolation of fluid around or through its substance. Porcelain inlays, as already explained, are now largely taking the place of gold in some classes of cavities.

If there are any cases in which the use of gold seems imperative, these are cases of slight decay in teeth towards the front of the mouth. In such positions amalgams are very unsightly, they are apt to discolour on the surface in most mouths, and porcelain inlays are very difficult to make well in very small cavities, unless free access can be obtained. Gutta-percha and cements in the small cavities in question do not answer well; besides they cannot be relied upon for many months, and need to be renewed over and over again in course of years on every sign of failure. Gold fillings once well done in such cases are extremely permanent, and are not more unsightly than others. In finishing them it is well in these situations to omit burnishing, and

to leave the surface after fine smoothing with Arkansas stone; this renders them less conspicuous.

Cases frequently present themselves, as for example, in neglected caries of a front tooth, in which a portion of the crown—the preservation of which, for the sake of the patient's appearance, is of great importance—is so extensively excavated as to form a mere thin shell of enamel, incapable of withstanding the force required in gold filling. In all instances in which the use of gold seems undesirable, the substitute best adapted to the circumstances must be employed. Every practitioner sees numbers of fragile front teeth preserved for years by non-metallic cement stoppings, and such an apparently perishable material as gutta-percha. Among the poor, numbers of grinding teeth must be lost were there not available any such material, at once so inexpensive and rapid of application as amalgam.

What seems called for in further description of filling in cavities after extirpation of the pulp is given at the end of the next chapter.

Some points regarding filling of teeth during childhood are discussed in a separate chapter.

AFFECTIONS OF THE PULP.

IRRITATION. EXPOSURE. INFLAMMATION.

In entering upon the study of diseases of the pulp, it cannot be too constantly borne in mind that the pulp has not, like enamel and dentine, a peculiar pathology totally differing in its phenomena from that of every other structure. The morbid changes which occur in the pulp are in their nature essentially the same as similar inflammatory processes in other vascular tissues. It matters not whether an iris, a synovial membrane, a lung lobule, or a dental pulp be the seat of the morbid action, these processes are the same, modified only by the anatomical peculiarities of the part. In the case of the pulp the following facts are to be considered: (1) The pulp being of very delicate structure, largely composed of cells, is very apt to undergo rapid degenerative changes under inflammation; (2) it is confined within the rigid walls of a chamber which allows neither of swelling, nor of the ready escape of exudations; (3) lesions of enamel and dentine are incapable of natural repair; (4) the exposed surface does not tend to cicatrize, and therefore, if a pulp is to be preserved, it needs to be hermetically sealed beneath an artificial covering. It is probable that inflammation, to at least a small extent, always speedily supervenes upon opening of the pulp cavity by decay, and that it

often precedes the actual exposure of the pulp. Any other analogous cavity, wounded, will speedily become inflamed if not kept aseptic by art. The condition of an exposed pulp might be, perhaps, broadly compared to that of the tissues exposed in a wounded joint or in a compound fracture. Septic matter may slowly percolate to the pulp through an intervening layer of dentine; and organisms may proliferate along the fibrils through carious dentine, which to the naked eye appears healthy. A single minute particle of septic matter, inoculating the pulp, would probably originate inflammation. These facts explain the occurrence of inflammation even before decay has apparently quite reached the surface of the pulp. Dentine of inferior structure, containing much organic material and numerous imperfectly calcified spaces would, of course, allow more easy passage for septic matter. In ill-made teeth the pulp cavity often extends in the crown—sometimes by a narrow, almost microscopical, process only—to a point abnormally near the surface. In such teeth numerous interglobular spaces are also commonly found in the dentine; and tissue readily permeable by fluids thus extends almost from immediately beneath the enamel to the pulp cavity. This accounts for the readiness with which inflammation often supervenes in the pulps of teeth of inferior structure, and notably in the first permanent molars at an early stage of decay, or after excavation of a cavity, and insertion of a filling in childhood.

These considerations cannot be too steadily kept in view, together with the fact that as pathological processes in the pulp are in their essence the same as those occurring in all vascular structures, so treatment must be based on those general principles which form the common foundation of practice throughout the whole range of surgery.

Irritation of the Pulp. Etiology and Pathology.—Dentine is connected with the pulp by means of the fibrils which permeate it and endow it with sensibility. This connection renders intelligible the facts, first, that influences may be communicated through the dentine to the pulp in consequence of disease or injury affecting that tissue; and secondly, that the condition termed irritation of the pulp, occasionally is produced during the progress either of caries, or of abrasion, or erosion of the hard tissues, long before the central chamber has been nearly approached or opened.* When the pulp is insufficiently protected only by a thin layer of dentine, it is, of course, liable to be acted upon more directly by external agencies.

Irritation of the pulp is pathologically nothing more than slight hyperæmia involving consequent pressure upon the nerve fibrils, and the condition may change to pronounced inflammatory action, especially in cases of caries, in which metallic fillings, rapid conductors of changes of temperature, have been inserted without previous treatment, or without a non-conducting layer beneath. If a pulp could be examined during an attack of irritation it would be found the seat of increased vascularity, disappearing with the cessation of the attack. Pulps which have been subject to long-continued irritation probably become always more or less calcified. But as calcification seems a normal phenomenon as age advances it is not possible to ascribe the change to morbid influences in every case. The newly-formed tissue is identical in structure with that already described as secondary dentine, and like it may be developed either in a layer organically united with the pre-existing tissue, or in isolated nodules

* "Abrasion" and "Erosion" are discussed in a later chapter.

scattered throughout the substance of the pulp.* When a layer of secondary dentine becomes developed over the surface of a pulp it protects the latter structure, and where wasting of the hard tissues is in progress, owing to attrition or erosion, it prevents exposure of the pulp, which would be otherwise in the end surely brought about. Secondary dentine of this kind is displayed in teeth which in course of years have been gradually ground down to the level of the pulp chamber by mastication. In such cases the pulp chamber when reached is almost invariably found perfectly obliterated at the surface by a mass of dentine united to the surrounding tissue, and distinguishable only by its yellow colour and sometimes by its extra sensibility. It is only in the very rarest cases that a similar effect is produced during slowly advancing caries. This is a remarkable fact which must be borne in mind. It matters not how slow the progress of caries, reparative or protective activity in the pulp may be said never to accompany it. Advancing caries always in time lays open the pulp chamber; it is virtually never found that a mass of secondary dentine shutting in the pulp has been formed in caries such as is always formed during slow attrition.

Diagnosis.—Irritation of the pulp is manifested by one symptom alone—namely, more or less dull aching pain, associated sometimes with a feeling of tenderness in the tooth, and with increased sensibility to changes of temperature; and it is not always easy to distinguish

* Mr. Hopewell Smith (Op. Cit.), proposes the designation "Adventitious Dentine" for this structure, and he differentiates several varieties beneath the microscope. In one there appears areolation similar to interglobular spaces; in a second variety, cells with nuclei are to be observed "caught suddenly, as it were, in the midst of the deposit"; a third variety displays very fine, straight fibrils; a fourth resembles the "ground glass-like matrix of hyaline cartilage," and a fifth variety displays laminæ arranged concentrically around a cell or nucleus.

between this pain and the aching arising solely from exposed dentine. Irritation of the pulp is much more frequent in young than in older patients.

It has already been pointed out that the pain arising from exposed dentine alone is, in some cases, more continuous and severe than in others. Failure to differentiate the two conditions, sensitive dentine and irritated pulp, is, however, practically of no importance, since the treatment is the same, and it may be said that merely sensitive dentine within a carious cavity almost invariably yields readily to treatment.

The absence of throbbing pain pathognomonic of inflammation of the pulp sufficiently distinguishes in many cases irritation from the more serious condition. In caries the nearer the exposure of the pulp the greater danger is there of a mistake in diagnosis, and unless a layer of dentine, unaffected by decay, exists in the depths of the cavity, excavation must be cautiously continued until the actual nature of the case is cleared up. The increased sensibility to changes of temperature which most teeth display to some degree after insertion of large metallic stoppings, and which usually ceases gradually in time without untoward result, was described in the section on filling materials. Sympathetic toothache, or that occurring in a sound tooth in the neighbourhood of others the seat of advanced caries, has been ascribed to irritation of the pulp, but the pain in most of such instances is much more probably neuralgic in character.

Treatment.—The treatment of irritation of the pulp varies somewhat in different cases, but the indications always are to remove the cause by protecting the exposed tissues from irritating influences, and to diminish the sensibility of the dentine. Where the dentine has become laid bare, owing to fracture of the tooth, or to attrition or erosion, and must remain ever

after exposed, its sensibility may be destroyed by solid chloride of zinc. Saliva being excluded and the surface left moist, a small fragment of zinc chloride may be allowed to deliquesce upon it. Nitrate of silver acts equally well, but discolours the surface. Neither of these drugs must be used if the pulp be nearly exposed lest they penetrate and set up inflammation. The same effect may be more slowly produced by frequent friction of the surface with spirits of wine, or better by the occasional application of absolute alcohol, and with this treatment may be advantageously combined the use of tooth powders containing astringents such as tannin, with alkalies like carbonate of soda.

When irritation of the pulp exists in connection with caries—by far the most frequent cause—the permanent filling of the cavity is, in the great majority of cases, sufficient to effect a cure. Caution must, however, be exercised, and it must be remembered that in some few instances, the insertion of a metal filling in a cavity even of slight depth in the dentine is enough in time to excite acute inflammation of the pulp. This untoward result may be brought about by sudden changes of temperature, which metallic fillings convey. The danger is necessarily in proportion with the extent of decay, and in deep cavities, and where the pulp is nearly approached it is imperative to shield it by a layer of non-conducting cement, in the manner which has been already described. When this precaution has not been previously carried out the metal stoppings must be removed and a non-conducting layer put beneath. In many cases it is a good plan to insert a temporary filling of non-conducting material. The sealing up of a cavity for a few months with a non-conducting filling material, particularly cement, is often alone sufficient both to abate sensibility of the dentine and to cure irritation of the pulp. The

cavity will have been, of course, excavated and prepared, and if then dried with absolute alcohol and the hot-air syringe the effect will be more sure. In these cases, unless the pulp be nearly approached, oxychloride cement may be used with advantage owing to its obtunding effect upon dentine.

When all symptoms of irritation have subsided the cement can be removed, with the exception of a thin layer over the floor of the cavity; even in comparatively shallow cavities this may with care be managed, and over this a permanent filling can then be packed. Cement needs to be buried sufficiently deep beneath the harder stopping to make certain it is safe from approach by the fluids of the mouth, which might act upon and destroy it.

Exposure of the Pulp.—Exposure of the pulp may be due to injury—fracture of the tooth—or to caries. The former class of cases is discussed under its proper heading in a later chapter. By far the commonest cause is caries. Exposure is sometimes accidentally caused during preparation of a cavity for filling.

In the last chapter the treatment of uncomplicated caries was discussed, and the precautions were described which ought to be taken to prevent the laying open of the central chamber of the tooth during excavation of carious tissue and preparation of the cavity for filling. In some cases this accident will unavoidably happen in consequence of abnormal extension of the chamber towards the surface.

The diagnosis of exposed pulp can be made certain only by careful examination with magnifying mouth-mirror and fine-pointed exploring probe. Pain, the only symptom, may not have occurred, and when existing it varies so much in amount and intensity in different patients, and under changing conditions in the same

patient, that it is never safe to draw a conclusion from this sympton alone. In one case an exposed pulp, or even exposed dentine alone, will from the first give rise to frequent or continuous severe toothache; in another the pulp cavity may be fully open for months without the patient being aware of the fact. A pulp must be considered exposed not only when it is actually laid bare by complete disintegration of dentine, but also when it is covered merely by a disorganised layer of tissue permeable by fluids and micro-organisms. The practitioner, familiar as he ought to be with the internal anatomy of each class of tooth, and having in view the position and extent of the pulp in average examples, will in a vast number of cases in examining a carious cavity perceive at once whether decay has nearly approached the pulp; in many cases he will be tolerably sure there is exposure before he has actually verified the fact. The only cases in which doubt is likely to exist after excavation of the cavity are those in which the exposure is extremely small—sometimes, as just stated, it is almost microscopical—as when it occurs at the extremity of a minute projecting horn of the pulp chamber. It must be always recollected that the pulp chamber often extends abnormally near the surface, sometimes by narrow slit-like prolongations, which may be extremely fine or even so minute as not to be visible by the naked eye. These, perhaps, occur most often in teeth with spinous crowns pinched in shape. In some cases, the patient by the act of sucking the cavity, can cause a minute drop of blood to exude from an opening in the pulp chamber otherwise invisible.

Excavation and examination of a cavity where exposure of the pulp is suspected should be performed with caution and gentleness. To plunge an excavator or search-probe roughly into a pulp is to inflict a pang of

exquisite pain, likely to be followed by a shock of greater intensity than is commonly recognised—a shock which may be seriously injurious to a delicate patient.

If in a case of exposure the pulp be free from disease the operation of "capping" the pulp, followed by filling, may be performed. Such cases would be more particularly those in which accidental perforation of healthy dentine had occurred. The smaller the exposure the greater the liklihood that the pulp is not diseased. The healthiness of the pulp may be inferred from the history of the case, and the absence of the signs and symptoms of irritation and inflammation.

The object of capping an exposed pulp is to provide a covering which shall protect the sensitive structure from pressure and from changes of temperature. Various materials, such as quill, parchment, gold-beaters' skin, court-plaster and thin sheet cork, are used for the purpose by different operators. The smaller the opening into the pulp chamber the less solid the material composing the cap may be, and when the exposure is extremely slight a fragment of parchment paper or bibulous paper may answer the purpose. The smaller the exposure the easier it is to arrange and fix a cap in position. After excavation and preparation for filling, the cavity should be freely washed out by means of a syringe with warm water, or mopped with a solution of carbolic acid (1 in 50), or aqueous solution of perchloride of mercury (1 in 4,000), or another antiseptic of similar strength, and should then be dried.* In this latter part of the operation in these cases neither alcohol nor the hot-air syringe must be used, nor any similar application likely to cause inflammation. A piece of the chosen material having been cut of suitable shape and size is next

* See Appendix C, Antisepsis in Dental Surgery.

carefully fixed by the plugging tweezers over the opening into the pulp cavity, resting upon the margins of the opening and closely in contact with, whilst at the same time not pressing upon, the subjacent pulp. Pressure upon the pulp will surely excite inflammation. In some cases where the exposure is extensive a concave cap of thin metal having a slight film of cement towards the pulp may be employed. The cap being thus arranged, the filling of the tooth may be proceeded with.

The success of the operation no doubt depends upon preservation of the pulp in a perfectly aseptic condition, and in the arrangement of a cap which while protecting shall not press upon the pulp. The cap and everything which is brought into contact with the pulp ought to be rendered aseptic by dipping in solution of carbolic acid (1 in 50); or, better, an aqueous solution of perchloride of mercury of equivalent strength, about 1 in 4,000; and the cavity should be repeatedly mopped out with the same solution.

A pulp exposed only to the smallest possible degree, as happens when a projecting fine process of the chamber is barely touched, may be covered without a cap with a thin paste of cement mixed with a small quantity of carbolic acid to render it aseptic, and over this more cement may be inserted.

Seeing that irritation, or even inflammation, of the pulp sometimes follows this operation, even in the best managed cases, and that the danger of this mishap is increased after insertion of a metal plug, which requires great pressure in packing, besides being a rapid conductor of heat, it appears desirable to cover the cap and complete the filling with gutta-percha or with one of the cements which does not contain chloride of zinc, this substance having a very irritating effect upon the pulp. These fillings are non-conductors, can be

inserted without pressure, and are readily to be removed on the occurrence of untoward symptoms. The first portion of the filling mixed very thin, mingled with a few fibres of cotton wool, can be conveyed as a very loose pellet to the cap and gently packed over its surface.

A cement filling may be trusted to endure at least for a few months; and within that time, if all go well, it may be excavated, with the exception of a protective layer over the depths of the cavity, and may be replaced by a more lasting material.

Such is the process of capping the pulp; but it must be understood that the number of cases in which the operation can be performed with fair prospect of success is really very limited, and it will be found better practice in a vast majority to extirpate the pulp and fill the roots —an operation described in later paragraphs. In the first place it is very difficult to make perfectly certain that a pulp which has become exposed or nearly exposed by caries, although apparently healthy and although perhaps remaining free from pain when covered by a dressing and temporary filling, may not have undergone pathological changes which prevent it from being brought into a healthy condition. It has already been mentioned that a pulp, the seat of the inflammation, is very prone to undergo pathological deterioration or degeneration. Such a pulp if capped and sealed beneath a permanent filling may remain quiet for a short time but will probably sooner or later pass into a state of active disease. The cases are very exceptional in which exposure in a carious cavity is traumatic—that is due to a lesion of the pulp chamber through accidental perforation or removal of healthy dentine, and of course these cases would be the most favourable for capping. In the second place the operation to succeed calls for the

most exquisite certainty in manipulation, so that owing either to the inaccessibility of the cavity or its unfavourable form, the difficulties in a great number of instances are almost insurmountable. The easiest cavity with exposure of pulp to deal with would be one in the centre of a molar crown with good solid walls around; perhaps the most difficult would be exemplified by one on the distal surface of the neck of a bicuspid. In a case like the latter, the difficulties of manipulation are extreme, and with a cavity so shallow as it must be in that position, it is all but impossible to fix a cap covered by a sufficient layer of non-conducting material over a living pulp. Similar difficulties will present themselves in numerous instances, and the operator must weigh the possibilities of failure under this treatment against those likely to occur under another.

Inflammation of the Pulp. Etiology, Symptoms and Pathology.—This is the commonest affection of the dental pulp. Its most frequent cause by far is caries which, having laid open the central chamber of the tooth, has exposed the structure within to the action of the atmosphere and external irritants. It may arise from irritation communicated through the dentine when that tissue has been penetrated to a greater or less extent, or may be excited by exposure to cold or frequent changes of temperature after insertion of a large metallic stopping. In rare cases it originates as an extension of inflammation which, having commenced in the periosteum, has involved the dental vessels and nerves in their passage to the pulp cavity through the foramina of the root. A blow on a sound tooth, loosening it or partly dislocating it, will occasionally be followed, sooner or later, after lapse of time, by acute inflammation of the pulp. In some very rare cases,

acute inflammation arises in teeth perfectly free from caries, and with no history of injury or of periostitis.

Two cases of this kind have been observed by Mr. England. In one case, acute inflammation came on in the pulp of a perfectly sound upper molar in the mouth of a lady, convalescent from typhoid fever, and ran a rapid course, with death of the pulp. The second case affecting a perfectly sound upper canine, and running a similar course, occurred in the person of a leading London physician, who had just passed through a severe attack of influenza. In both of these cases, although violent toothache was present, the pain was, at first, to a large extent neuralgic in character; and as both patients had paid great attention to their teeth, and were aware they were in good order, the pain was, at first, ascribed to pure neuralgia, following the lowering attacks of illness. Attention being at last directed to the teeth, the pulps were found dead on applying the heat test and drilling into the chamber.

Inflammation of the pulp assumes either an acute or chronic form. Suppuration, ulceration, degeneration, gangrene, or outgrowth of new tissue may result.

Acute Inflammation.—Pain is the most prominent symptom of acute inflammation of the pulp. It varies in amount according to the extent and intensity of the inflammatory action. It is more severe in some individuals than in others—in the young than in the old—and in all is increased by some derangements of the general health, of which pregnancy affords the most remarkable example. The greater pain in the young may be accounted for by the great size and vascularity of the pulp. As explained and described in the chapters on physiology, the pulp becomes diminished in bulk by calcification, and often undergoes degeneration as age advances. In pregnancy, in debility, and in

other disorders of health, the pain frequently takes on the character of neuralgia—as will be explained in the chapter on that disease.

At the commencement of an attack the pain is dull and aching, confined to the affected tooth, soon assuming a more intense lancinating or throbbing character—a character pathognomonic of this affection, among inflammatory conditions within and around the teeth—and finally becoming almost intolerable, it appears to spread to the adjoining teeth and to the whole side of the head and face. The pain of this form of toothache is more severe than arises in any other dental disease, and its severity is accounted for by the fact that the pulp, a highly vascular and nervous substance, is confined within the rigid walls of a chamber where swelling is impossible, and whence the inflammatory exudations cannot freely escape.

The tendency of acute inflammation of the pulp, which runs on unchecked, is to terminate in gangrene or sphacelus, but this termination is of most frequent occurrence when the pulp cavity is but slightly opened, or where the pulp is altogether confined beneath a layer of dentine, or beneath a filling. Under such circumstances, there being no room for swelling, and little or no escape for the inflammatory exudations, such tension or constriction is produced as soon causes death of the whole mass. The occurrence of death of the pulp may be recognised by the cessation of the more acute pain and by the insensibility of the dentine; whilst on examination the pulp is found devoid of sensation, softened and discoloured, and emitting a characteristic fetid odour. The entire tooth at the same time assumes a darker tint, and occasionally becomes stained to various hues in consequence of the diffusion of the colouring matter of the blood of the pulp through the

dentine. When death of a pulp has supervened in a tooth free from decay or in a filled tooth, a diagnosis is to be made by the heat test. This test is carried out by applying a hot metal instrument to the surface of the tooth, over the situation of the pulp chamber. A smooth-headed steel burnisher is best for the purpose, and it can be readily heated in the flame of a spirit lamp to a temperature which would easily excite sensation in a tooth with a living pulp.

An attack of acute inflammation when the pulp is freely exposed rarely produces gangrene of the entire structure. The inflammation is sometimes limited to the exposed surface alone. In many cases, where extensive exposure permits it, swelling takes place, and the exudation having found vent the attack slowly subsides and assumes a chronic form, to be renewed again and again from time to time under the influence of increased irritation. An attack of acute inflammation is sometimes cut short by the patient's act of sucking the tooth. The air being exhausted from the cavity, the congested vessels are ruptured, bleeding takes place, and the tension is at once relieved.

If a pulp, the seat of acute inflammation, be examined recently after the extraction of a tooth the affected portion will be found deeply red in colour, the vessels being visibly injected, and small patches of extravasated blood will be observed upon the surface. Where swelling has been possible a red œdematous surface, studded with suppurating patches, may be found projecting into the carious cavity through the opening into the pulp chamber. Some amount of suppuration is almost always present, but it is generally confined to the exposed surface, and abscess in the substance of a pulp is rarely formed. The general characteristics of a pulp in which gangrene has supervened have been already mentioned.

Close examination shows that the tissues in this condition exist sometimes as an ashey grey slough retaining the form of the pulp. In other cases the pulp tissues are reduced to a semi-fluid mass of a dirty reddish-grey or yellow colour. In this mass portions of the disintegrated walls of the blood-vessels, with numerous fat-cells interspersed, and disorganized nerve fibrils, may be traced by the microscope. There is a marked foul gangrenous odour. Pulps exposed for a considerable period to the atmosphere and external irritation, and having undergone repeated attacks of acute inflammation, although they may exhibit on the surface only congestion or very limited inflammation, often show on microscopical examination marked pathological changes in the deeper portions throughout their structure. These changes are similar to those found in all highly vascular and cellular structures the seat of inflammation. They very often partake of the character of fatty degeneration affecting both vessels and nerve fibrils. Caseous degeneration is sometimes recognisable, and atrophy is often well marked.

The bacteriology of inflammation of the pulp and its sequels, suppuration and gangrene does not differ materially from that of other vascular structures of similar physiological character and under like anatomical conditions. Several varieties of staphylococcus such as *s. pyogenes aureus*, *s.p. albus*, and *s.p. citreus*, have been distinguished, as well as various bacilli in suppurating pulps; and Professor Arkövy, of Budapest, states that there exists an organism peculiar to gangrenous pulps, and this he styles *Bacillus gangrænæ pulpæ*.

Diagnosis.—The diagnosis of acute inflammation rarely presents any difficulty. Careful examination must be performed, for the patient will often point to the wrong tooth, and will frequently imagine that a broken-down

neighbouring root—not the seat of active disease—is the cause of pain, which really arises in a cavity the existence of which had not been suspected. The character of the pain can hardly be mistaken, whilst in the vast majority of cases, there exists a carious cavity in which after excavation of the softened dentine the pulp is exposed and visible. Where the opening is extensive the surface of the pulp may be seen red and injected with blood or dotted with suppurating points, and it bleeds readily and freely if touched. From dental periostitis inflammation of the pulp may be distinguished by the fact that in that disease the earliest symptom is tenderness upon pressure, and slight elevation of the tooth in the socket, whilst, where the pulp is alone inflamed, it is not until a later stage of the affection—when, in fact, the inflammation has extended to the periosteum—that these symptoms are displayed. When the intimate connection of the vessels entering the pulp with those of the periosteum is considered, it will be obvious that some congestion of the periosteum or even periostitis must often accompany inflammation of the pulp; and care must be taken in diagnosis not to mistake the case for one of periodontitis alone. The patient will often complain of pain on exposure to a current of cold air—as for example the drawing of air into the mouth—and the contact of hot or cold fluids will sometimes give rise to a more or less severe paroxysm of pain. It must be noted that the pain passes off rapidly when the local irritant is removed, in this differing from acute periostitis in which the pain is of a persistent character. Pain on pressure by means of a small pledget of cotton wool conveyed by plugging tweezers, and forced gently home into the depths of a cavity in which an exposure of the pulp is suspected, is a valuable diagnostic sign.

A tooth the seat of acute inflammation of the pulp

will always display some sensibility under percussion; but this will be comparatively slight until the whole pulp down to the apical foramen has become involved, and then the sensibility to percussion will not be very great. Percussion is performed by smartly tapping the surface or cutting edge of the crown in the direction of the root with a steel instrument, such as the handle of an excavator. Pressure on the tooth causes little pain unless the cavity be entered and the exposed pulp pressed upon, and then very often a momentary pang of extreme severity is inflicted. On the other hand, periodontitis, by the time it had advanced to produce as much pain as accompanies acute inflammation of the pulp, would have rendered the tooth exquisitely sensitive to the least touch and so raised in the socket that the jaws could not be closed without great pain.

Treatment.—The treatment of acute inflammation of the pulp must be modified in accordance with the circumstances of the case and the phase which the process has assumed. In some instances the extraction of the tooth is called for; in rare cases the reduction of the inflammation and the conservation of the complete vitality of the tooth may be reasonably aimed at; whilst in a third group, forming the majority of cases, extirpation of the pulp and root filling is the proper treatment.

The extraction of the tooth is most frequently required in childhood, when the first permanent molar is the seat of disease. At this period an attack of acute inflammation usually runs a rapid course, the pain becomes excruciating, the inflammation quickly spreads to the periosteum, and the tooth becomes so exquisitely sensitive to the touch that manipulation of any kind is unbearable. The rapid spread of the inflammation in these cases is accounted for by the yet incomplete

condition of the roots, the apices of which are represented by a portion of uncalcified pulp, freely communicating with the alveolar tissues. This condition in early childhood renders inadmissible any attempt at the destruction of the pulp by means of escharotics in the manner presently to be described. The advantages previously referred to (in the chapter on "Irregularities"), which in many cases accrue from the extraction of the first permanent molars (the teeth by far the most frequently the seat of caries in children), render their preservation inexpedient after the appearance of the second molars. In the temporary teeth, the roots of which are undergoing absorption, the course of acute inflammation of the pulp closely resembles that which takes place in the permanent teeth at the same age. The treatment of these cases is more fully entered into later in a separate chapter.*

In the case of children, as in every other case of acute inflammation of the pulp in its earlier stages, the attack may be often cut short by removing the cause. With this view the cavity should be excavated, and in doing this with proper care it is possible to avoid pressing upon the pulp and inflicting severe suffering upon the patient. Spoon-bladed excavators, thoroughly sharp, are the best for this purpose. With them foreign particles and afterwards softened dentine may be scooped away without danger of the instrument plunging into the pulp. The sensibility is too extreme to allow the use of drills in the immediate vicinity of the inflamed surface. Pure carbolic acid will help to diminish the sensibility, and a minute quantity may be carried in at intervals during excavation on the blade of a spoon excavator and applied to the exposed surface.

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* See Chapter on "Caries and its Sequels in Childhood.'

Where a stopping is present it must either be perforated with a sufficiently large opening or entirely removed. This is best accomplished with sharp spear-pointed drills. When of amalgam the stopping may be the sooner broken up if as the drill proceeds a small quantity of mercury conveyed in the form of semi-liquid amalgam be applied to the surface and worked in with the drill. The mercury helps to disintegrate the mass.

Foreign particles pressing upon the pulp may be dislodged by the excavator, aided by the syringe and warm water, the free use of which should be continued to encourage bleeding from the exposed surface, should it occur. Great care being taken not to cause pressure, the cavity may be then lightly filled with a temporary plug of cotton wool saturated with mastic solution, or soft gutta percha, over an antiseptic dressing such as a pellet of wool moistened with equal parts of carbolic acid and eucalyptus oil, or oil of cloves, or eucalyptus oil and iodol; and external irritation being thus guarded against, the inflammation will often subside. The dressing and temporary filling may be renewed at intervals of a few days. When all symptoms have disappeared—when pain and discharge have ceased, and when the exposed pulp surface, if visible, is no longer red—the operation of capping the now healthy pulp and filling the tooth may be proceeded with. The rare cases favourable for this treatment are those in which the periosteum is unaffected, and in which the pulp fully retains its vitality, not having been partly destroyed by gangrene or ulceration resulting from former attacks of inflammation, and where the difficulties spoken of in the section on capping the pulp do not exist. The ordinary difficulties and dangers to the tooth attending attempts to save by the operation of capping a pulp free from disease, are increased where morbid activity has existed; and few practitioners will

nowadays incur risks which can be certainly avoided and with advantage by another course of procedure.

In acute inflammation of pulp following upon insertion of a permanent filling, as sometimes happens after capping, or when the pulp has been protected by but a thin layer of dentine, the tooth often passes in a few hours into a condition of such exquisite tenderness as to make the removal of the filling unbearable. In such cases it is good practice to drill a small hole through the tooth or stopping into the pulp cavity. This gives vent to the inflammatory effusions and relieves the pain. The filling being removed later the pulp can be dealt with as circumstances direct. This operation is also called for in those cases mentioned above, in which acute inflammation of the pulp occurs after injury—such as a blow—to teeth in which no cavity exists. In these cases, there being absolutely no vent for inflammatory exudation, the pulp will often, after a short course of the disease, be found sphacelated on opening the tooth. It is very often possible in these cases to convey a dose of arsenic to destroy the pulp through the hole made by the drill. The hole having been first well syringed with warm water to wash away *débris* and encourage the escape of exudations, a minute pellet of wool bearing the arsenic can be passed on the end of a steel wire to the surface of the pulp.

From what has been urged in previous paragraphs it will be evident that in the vast majority of cases of acute inflammation, attempts at preservation of the pulp are contra-indicated. The best treatment in most cases consists in destroying its vitality by means of arsenious acid, in extirpating it, and afterwards permanently filling the chamber and root canals, as well as the external cavity of decay.

A very minute quantity—less than $\frac{1}{20}$th of a grain of

the escharotic—is sufficient to destroy the vitality of the pulp of the largest molar. The arsenic for this purpose is reduced by trituration to an impalpable powder. The mode of applying it is as follows:—The cavity having been excavated and dried, the arsenic is carried to and gently laid upon the exposed surface of the pulp by means of a fragment of amadou, or of bibulous paper, or a few filaments of cotton wool rolled into a tiny pellet moistened with carbolic acid, and is then at once sealed in by a filling. It is important, in the first place, to ensure access as free as possible to the pulp by cutting away dentine when necessary; in the second place, to apply sufficient arsenic to devitalize the pulp, not to set up merely inflammation. If the arsenic does not gain ready access, or if too small a quantity be applied, the effect stops short at causing inflammation, and this in some cases extending to the periosteum leads to suppuration and loss of the tooth. When effectually applied arsenic rarely causes much suffering. If pain continue after a few hours the temporary stopping should be removed, and a renewed careful application ought to be made. The action of arsenic being usually rapid, the treatment of clearing the cavity and applying it often indeed serves to arrest almost instantly the suffering arising from an aggravated attack of inflammation of the pulp.

There are some disadvatages attending the use of wool with mastic solution, or gutta percha, or other ordinary temporary stopping, as a covering for the escharotic. With them it is sometimes difficult to avoid pressure upon the exposed pulp, an accident which is attended with great pain, whilst the liquid constituents of some fillings tend to wash away the pulp-destroying dose. These disadvantages are overcome by the use of bees'-wax as a temporary filling.

Or better still, the "hard wax," commonly used for joining together the various parts of mechanical appliances when trying them in the mouth. Small pieces of wax are carried by plugging tweezers to the cavity, and by means of a small heated spatula melted within the orifice, so as to effectually exclude saliva for a few hours. The spatula should have a wooden handle and a short metal blade, so as to avoid burning the patient's lips. The danger of causing pain by pressure upon the exposed pulp increases with the solidity of the temporary plug, but in careful hands the soft gutta percha supplied for the purpose will, in some situations, answer best. In some instances, a pellet of dry cotton wool may be laid over the dressing beneath the temporary stopping. If in any case a more solid plug seems called for cement may be used, and the deeper portion of this may be mixed with a few fibres of cotton wool and spread as a cap over the pulp chamber.

Care must be taken to prevent arsenic escaping from the cavity on to the mucous membrane of the gum or cheek. If this occur a very painful ulcer may be caused. The accident is most likely to happen in cavities at the neck of the tooth and on the buccal aspect. Extra care must be taken in these cases to effectually seal the cavity, and to press away by wedging or by previous treatment the fold of swollen gum which so often is found encroaching upon the orifice.

The temporary filling may be removed in about twenty-four hours, when a cautious examination may be made. It is only in a proportion of cases, and particularly in single fanged teeth, that application of arsenic is followed at once by total destruction of vitality and sensibility throughout the pulp. In most

cases, however, the sensibility is so diminished that extirpation can be easily borne.

When, perhaps owing to the exquisite tenderness of the part, it is impossible to procure a free exposure of the pulp previous to the application of the destroying dose, it is well to warn the patient that he is likely to suffer some pain during the operation of the arsenic. After a few hours—three or four are often enough—the dressing can be removed. It will then, in most of such cases, be found that the pulp surface has at least been destroyed, and the surrounding dentine rendered insensitive. Further excavation can then be practised, and a dose of arsenic can be again applied. Nodules of secondary dentine in the pulp chamber and roots often prevent access of the escharotic to the depths. These must be cleared away by drill and excavator. In molars, destruction of the pulp will often require lengthy treatment of this kind, owing to obstruction in the several roots.

Sometimes apparent sensibility of the whole pulp is really due to a small shred in the depths of a root canal which has escaped the action of the arsenic—pain arising when pressure or traction is exercised at the surface.

The effects of arsenic upon the pulp are stated to be as follows:—It first produces hyperæmia followed by thrombosis; it is then taken up by the vessels, producing granular degeneration of their contents, and finally shrinkage and collapse of the vessel walls. The connective tissue and odontoblasts are unaltered, the other cells swell to three or four times their natural size. The axis cylinders of the nerves undergo granular degeneration. Arsenic has practically no effect upon dentine.

In repeating applications of arsenic the amount applied will be dimished in accordance with the mass of

pulp already destroyed; an extremely minute quantity, $\frac{1}{100}$ to $\frac{1}{50}$ of a grain is enough to destroy the contents of a root canal of average size if applied effectually to the surface.

It is not desirable to carry arsenic into the depths of root canals. Minute shreds of pulp may be destroyed by pure carbolic acid. Throughout the whole process of extirpation of a recent pulp carbolic acid is useful. It forms at once a local anæsthetic, an escharotic and an antiseptic. It can be conveyed on a pellet of cotton or carried in the blade of a spoon-shaped excavator to the pulp cavity and can then be gradually worked into the canals on the nerve-extracting instruments, or on a bristle with a few fibres of cotton. The properties which particularly fit carbolic acid for this operation, render it less suitable than perchloride of mercury and some other antiseptics in procedures where escharotic action is not required.

The devitalization of the pulp of single rooted teeth—incisors and canines—can be effected instantaneously by means of instruments alone, but the pain is extreme unless the pulp has been previously destroyed to a great extent by disease when it is not so severe as might be supposed. The operation is peformed by thrusting rapidly a thin flexible steel bristle to the apex of the canal, and rotating it so as to sever at once the vascular and nervous connections of the pulp. An anæsthetic (nitrous oxide answers well) should be given if great pain is anticipated; otherwise the shock of the operation is enough seriously to affect any but an uncommonly robust patient.

Extirpation of the dead pulp of teeth with single and nearly straight canals is mostly a simple procedure, but difficulties present themselves and often become great in teeth with several roots. A large proportion of such

teeth present irregularities in the number of the roots; both upper and lower molars often have extra roots, whilst the form and the size and shape of the canals vary extremely. The first step consists in cutting away the margins of the cavity of decay and laying open the pulp chamber so as to allow access to the canals, and to permit passage of nerve extractors without great bending. When the chamber is well open it is sometimes possible to extract the pulp in one mass together with the contents of one or all of the root canals. A crook-ended instrument—a small curved-bladed excavator answers well—is passed into and entangled within the substance of the pulp. Gentle traction and manœuvring then exercised have often a successful result. The pulp chamber. which often contains nodules of secondary dentine, can be easily cleared by burs and excavators, and the *débris* having been syringed away the number, position, and direction of the root canals may be discovered. The cavity may next be dried, and moisture being excluded nerve extractors may be brought into use. The best extractors consist of extremely fine, highly-tempered steel wire, some having a single barb at the extremity, others with a series of barbs; and these latter are most useful in the larger canals. Instruments with many barbs and also some of spiral form preferred by some operators are illustrated in figs. 197 and 198.

In using nerve extractors the aim should be to remove the contents of each canal intact. This is to be done by passing the bristle to the apex of the canal, and rotating it so as to entangle and withdraw the mass. This is an operation which demands patience and lightness of touch. An attempt to tear out roughly the contents of the root canal always fails. The barbed bristle should be passed gently along the canal until it is

felt to reach the apex. It can then be gently rotated and worked slightly to and fro until entanglement of the pulp—which can often be recognised by the fingers—has been effected. Cautious withdrawal of the instrument may be then begun; but if the pulp still remains the nerve extractor can be passed back and again manipulated. In spite of care and skill it will often happen that a pulp can only be withdrawn piecemeal. The appearance of an entire root-pulp is characteristic—

FIG. 197.

FIG 198

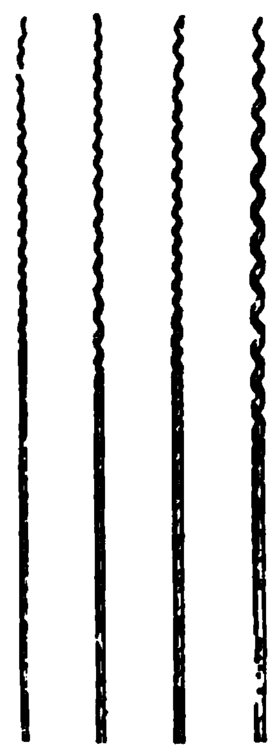
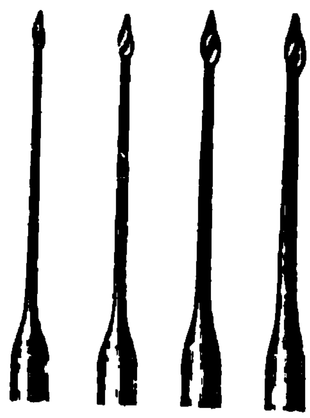


FIG. 199.



the mass gradually diminishing in size until it ends in a minute drawn-out shred, the point of its termination at the apical foramen.

Throughout the operation antiseptic precautions must be taken. Carbolic acid may be used so long as the pulp displays any sensibility; afterwards perchloride of mercury in spirit—a strength of 1 in 3,000—may be used, and this can be pumped into the canals from time to time by means of a minute wisp of cotton on a bristle. Where putrefaction has not occurred asepticism may be

ensured by free washing with water; but as it is very difficult to inject a stream of water into the depths of root canals it seems better to employ antiseptic agents.

It is not necessary or desirable to use the drill to clear canals unless they are obstructed by secondary dentine or unless it be impossible otherwise to make certain the pulp is entirely removed. This is sometimes the case where canals are very small in calibre and tortuous in direction; but a canal which will let pass the smallest bristle need not be drilled as a rule. Drills with thin flexible shafts and flame-shaped points are most useful for this purpose. They are depicted in fig. 199.

In neglected cases in which canals have been allowed to retain putrid contents long after death of the pulps—cases which will be presently discussed—it may be more commonly necessary to use the drill, but where the pulp is freshly destroyed deep drilling is to be avoided. It is, however, usually desirable to enlarge to a slight depth the orifices of the canals in the pulp chamber. This is often called for to facilitate entry of nerve extractors, and to prepare for the filling of the canals. To drill the whole length of a canal is a difficult operation, particularly in a distorted root. In an attempt to carry a drill beyond a point where the canal makes a bend there is always great danger of perforating the root, or if not perforated, the inner surface of the cement may be closely approached or touched, and inflammation (periodontitis) may be excited at once or may supervene later. In all cases there is danger of wounding the alveolus through the apical foramen and setting up inflammation; and then there is also danger of breaking the drill, which must be of necessity fine, flexible and delicate. Neither a broken drill nor a nerve extractor nor other instrument must ever be allowed to remain. If they cannot be withdrawn they must be destroyed by

tincture of iodine. The tincture must be worked in and a temporary plug inserted to give time for corrosive action upon the steel. It is often possible to drill to sufficient depth round the broken instrument and to seize it with a pair of forceps having very fine and narrow beaks expressly adapted for passing down the root canal. In the case of broken barbed instruments, a wisp of cotton wrapped round a bristle and passed down the root will often become entangled in the barbs on withdrawal and bring the broken fragments away. Throughout the operation of drilling the instrument on each application must be dipped into carbolic acid or some other antiseptic.

Some slight hæmorrhage from the canal, not amounting usually to more than one or two drops, frequently follows the extraction of the terminal shred of the pulp. When this has ceased the filling of the canals may be proceeded with. The canals, after cleansing by the syringe and cold water, should be dried. Solution of perchloride of mercury (1 in 3,000) in either absolute alcohol or strong rectified spirit should be used in this part of the process. Shreds of cotton wool soaked in the fluid should be passed into each root and allowed to remain for a few moments, evaporation being hastened by the hot-air syringe. By this means the canals are more thoroughly dried and sterilised than is possible by any other method.

For dressing and filling roots steel bristles are required, and fine wire root-pluggers of different thicknesses. The finer bristles are best of watch-spring temper. Some of the bristles have barbed points; some are only slightly roughened at the end and some are smooth. For mopping out canals a few fibres of cotton are used with either a barbed or roughened bristle. When the cotton is to be left in the canal as a

dressing or stopping a rough-ended bristle is used. The end with a few filaments of cotton is taken between the thumb and fore-finger, and with a twirl the cotton is wrapped round the bristle. The cotton is then dipped into the fluid which is to be conveyed into the canal, and then may be made to take up from a slab a small portion of iodoform or of tannin, or such like solid ingredients of the dressing. The loaded bristle is then passed along the root canal. To disengage the dressing the bristle is gently rotated in the direction the reverse of that which was used to wrap the cotton fibres round. To pack the fibres more tightly when they are to remain as a permanent filling the bristle is used as a plugger, or when the calibre of the canal admits it a stouter root plugger is substituted. To withdraw a cotton dressing a barbed bristle is of course used.

There exists, virtually, no difference of opinion as to the principles upon which the operation of root-filling should be carried out. It is generally agreed that the canals ought to be hermetically sealed, and so preserved in an aseptic condition; that the stopping should be a non-conductor of heat, and not so hard as to be very difficult of removal in the event of untoward symptoms developing. Probably all are agreed upon these points. It is in the choice of material for the stopping where diversity of view is found, albeit the end aimed at is in any case the same.

The canal will, as a matter of course, have been sterilised and dried with absolute alcohol and the hot-air syringe immediately before filling.

Where the canals are of fair calibre and easily accessible, cement (not being zinc oxychloride) answers well. A small quantity, mixed thin, is carried to the entrance of the canal, and "coaxed" along by means of a steel bristle, having a few fibres of wool round the

point. It is important in all cases where using semi-fluid fillings to avoid a rough pumping action, which may drive some of the stopping through the apical foramen; hence the word "coax" will suggest the method, differing from careless pumping, which is best employed to carry the stopping to the depths of the canal. A few filaments of absorbent cotton may be mixed with the cement, and this very often suffices to carry it along. The canal once partly filled in the deeper portion, there is rarely any difficulty in passing in more and more stopping in small fragments, with or without a filament of wool. It is important to use a loose filament or two only, not a rolled pellet of wool. A pellet will often jam in the canal.

Either a solution of gutta percha in chloroform, or collodion, may be used in exactly the same fashion. With the former a small quantity of iodoform may be mixed; and with the latter it is possible to incorporate a small quantity of formalin, two to five per cent., and thus render the fillings antiseptic. Aided by a current of warm air these solutions harden in a few moments. Then, again, thin points of gutta percha are supplied specially for root fillings. Some operators prefer a mixture of wax and iodoform, others use shellac. These are introduced in fine drawn-out threads, and caused to flow into the canals by heated wire pluggers; or in the case of shellac, with the aid of a minute quantity of absolute alcohol in which it is soluble.

The smaller the canal the more the need of a stopping which will readily flow, and among these collodion and solution of gutta percha in chloroform are among the easiest to manipulate.

When the canals are filled and sealed the insertion of a permanent stopping may be proceeded with. It is, however, good practice in any case and imperative where

untoward symptoms are feared, to insert a non-metallic filling and leave it for a few months, so as to guard the tooth for a time from sudden changes of temperature.

Filling roots with gold, which was once, many years ago, considered the best practice, is a more laborious operation and presents no advantages over those just described. It is often necessary to open up the canals to a considerable extent before plugging instruments to carry in the gold can be made to enter, and it is difficult to maintain an aseptic condition. Gold is, moreover, a rapid conductor of heat; it is extremely difficult to remove when once packed, and its use in fang filling is often followed by periodontitis, a result which very rarely follows the use of antiseptic plugs such as those described and now most commonly used. Similar objections apply to amalgams.

It is only in exceptional cases that the whole process of root and cavity filling will be attempted at one sitting. Where several roots of one tooth are being dealt with it will often happen that one or other of the canals need more prolonged treatment than the rest. During the intervals between visits or in any case where it is desired to bring about and maintain an aseptic condition, the canals, after treatment with alchoholic solution of perchloride and drying with hot air, may be filled with shreds of absorbent cotton, moistened with equal parts of carbolic acid and eucalyptus oil or similar antiseptics. The cotton fibres are carried down the canals lightly twisted round the point of a steel bristle, and the cavity is sealed with a temporary plug.

Thanks to aseptic and antiseptic methods the operation of root-filling and stopping forms so successful a procedure that the practitioner mostly enters upon it without misgiving. The most favourable cases are those in which a septic condition of the canals has not

existed, the least favourable are those in which the canals have been occupied for prolonged periods by the putrifying pulp and decomposing *débris*. Even in the most favourable cases difficulties are apt to occur which render the operation more or less a failure; and these difficulties may now be discussed.

Abnormalities in the roots often exist. For example a second upper bicuspid—a tooth usually with one root only—may have a bifurcated fang; and the bifurcation may be unequal, one point being extremely minute so that it is practically impossible to recognise it with fine root instruments. Then again, upper and lower molars often have one or two extra roots; and these are often very small. Lastly, the roots of all teeth, but particularly molars, are apt to be so bent or twisted that it is impossible to pass a nerve extractor or a drill throughout their length. The openings of extra root canals into the pulp chamber ought always to be sought for after the normal ones have been located; but even careful examination will, owing to their minuteness, often fail to discover them.

A badly twisted root will sometimes baffle the most skilful operator, and he will sometimes find it impossible fully to clear the canal.

A portion of living or dead pulp left in a canal beneath a filling will, in most cases, give rise to inflammation sooner or later; and the patient will return in pain. When the operator is aware of the condition—as when a twisted root which cannot be cleared exists—the patient must be informed of the circumstances; and if he will submit to treatment the case, although unfavourable, need not be hopeless. First, if doubt exists as to the vitality of the remaining shred of pulp, the orifice of the canal can be enlarged and a minute dose of arsenic be applied to destroy it.

The other roots will have been first filled in the usual way, and on the next visit the cavity and the canal so far as possible can be dried by free application of absolute alcohol and the hot air syringe. An antiseptic filling can then be packed lightly into the orifice of the canal, and more firmly into the pulp chamber. This filling can be composed of absorbent cotton wool soaked in solution of perchloride of mercury, 1 in 1,000 or in formalin solution (1 in 50) the latter perhaps to be preferred. The spirit would be allowed to evaporate; the wool with formalin solution must be left moist. Over this a gutta percha or cement stopping would be inserted. The patient must be warned to return if pain appear. If no evil symptom arise this dressing and filling can be repeated in a few months; and after a further period of probation a more permanent stopping can be put in—the pulp chamber being always filled with an antiseptic plug of cotton. In favourable cases the dead shred of pulp becomes mummified within the canal and no evil results. In less favourable cases the shred decomposes and sets up inflammation through its connection with the peridental membrane, to which it is, in fact, attached as a minute slough; or a shred of living pulp having been left this becomes inflamed and involves the periosteum. Vent for the effusions existing within the tooth the inflammation often remains sub-acute, and the tooth becomes comfortable after a mild attack of toothache. In other cases the inflammation having spread to the periosteum, a small alveolar abscess forms and breaks through the gum, and the symptoms subside, a tiny fistulous opening through the gum remaining.* In unfavourable cases all the symptoms just named become aggravated, and return on every attempt to fill the tooth permanently after renewed treatment. These cases, in

* Alveolar abscess is discussed in the next chapter.

some instances, may be treated by the drilling of a small hole into the pulp chamber through the neck of the tooth, within the free edge of the gum, to give vent to discharges; and although this seems merely a temporising expedient, it yet sometimes serves to prevent the loss of a useful tooth for many years.

Chronic Inflammation of the Pulp arises from the same causes which originate acute inflammation, by far the most common being exposure of the pulp by caries. The surface of a pulp exposed in a carious cavity is probably always in a state of inflammation. The inflammation may remain throughout extremely slight, and pain may be rarely perceived. Acute attacks may supervene at shorter or longer intervals, under irritation or injury, as from pressure of foreign particles. Chronic inflammation usually always remains as a sequel to an acute attack, and again assumes a sub-acute or a more active character from time to time under the influence of increased irritation.

The pain, usually of a dull aching or gnawing kind, is less severe than in acute inflammation; it may be almost altogether absent if there be a free vent for the discharges, or may be manifested at a distance in the form of neuralgia. The exposed surface is red and swollen, and pours out a thin puriform or serous secretion having a characteristic phosphatic odour. On examination the redness, which is due to injection with blood, is found to be confined to the superficial portion alone of the pulp. This condition may resolve itself into a process of ulceration under which the pulp gradually disappears; in other cases degeneration and atrophy ensue, and effect complete destruction of the pulp, often with the occurrence of little or no pain.

In a certain number of instances chronic inflammation gives rise to the development of new tissue in the form

of polypus of the pulp. This occurs mostly in young subjects, in teeth the crowns of which are extensively excavated by caries and with the pulp fully exposed. The new growth consists of a rounded fleshy mass, red or bluish-red in colour, occupying or projecting from the cavity of decay, and may attain a size between that of a small pea and a Spanish nut. It is usually covered with an offensive muco-purulent secretion. It bleeds readily if wounded, but displays little sensibility. Examination shows that polypus is united with the pulp, from which it springs, and that it consists of a mass of rounded and spindle-shaped cells, supported by a small quantity of fibrous tissue, and provided with numerous comparatively large blood-vessels.

Treatment.—In cases of uncomplicated chronic inflammation of the pulp in which there is neither an outgrowth of new tissue (polypus), nor loss of substance from ulceration or gangrene, nor periostitis of marked extent, it is sometimes recommended that an attempt should be made to bring the structure into a healthy condition. With this object, the cavity having been excavated and antiseptically cleansed, a dressing of carbolic acid on cotton wool may be lightly applied to the pulp, covered by a temporary filling. There is, in most instances, a discharge having a characteristic phosphatic odour from pulps in a state of chronic inflammation. This discharge will stain a wool dressing from which the odour will be perceptible, and, until this ceases, antiseptic treatment must be continued. Later, this may be followed by similar treatment with eucalyptus oil, the dressing being renewed at intervals of a day or two, until all symptoms of inflammation have subsided. The operation of capping the pulp and filling the carious cavity must then be carried out in the manner already described.

There can hardly be a doubt that with very rare if any exceptions, cases of chronic inflammation are best treated by destruction and extirpation of the pulp and fang filling. This is to be carried out exactly by the same means and methods as prescribed for acute inflammation.

In the vast majority of cases in which there has occurred an outgrowth of new tissue sufficient to constitute a polypus, the extraction of the tooth is the sole treatment that can be recommended. In childhood, before the period when complete calcification of the roots has been effected, any treatment save extraction cannot of course be entertained. In some instances the polypus may be excised, the pulp extirpated, the root canals cleared, and the truncated tooth may be "crowned" or otherwise dealt with as explained in a later chapter. The polypus can be easily excised with a large sharp spoon-bladed excavator. Polypus has usually very little sensibility, and this can be diminished by swabbing with pure carbolic acid, with the usual care not to allow the acid to flow on the gums around. The cases most suitable for this conservative treatment are those in adult patients in which the new growth is small and in which symptoms of periodontitis and its sequels are absent. Before proceeding to "crown" the tooth in such a case it is well to fill it temporarily and leave it for a probationary period.

It frequently happens that after repeated attacks of acute or long-continued chronic inflammation the pulp is entirely destroyed. On examination the canals are sometimes found to contain the gangrenous pulp entire —an ashy grey-coloured, more or less coherent mass with the characteristic odour, or merely a semi-fluid mass of decomposing tissues. In other instances the pulp cavity and canals may contain only fluid and foreign particles, all trace of pulp tissue having disappeared,

The existence of these different conditions is governed by the length of time which has elapsed since the death of the pulp. Very often years may have passed before the case comes for treatment. These cases are sometimes classed as "pulpless teeth."*

The treatment in these cases consists in thoroughly clearing out the canals, and in disinfecting them by the application of antiseptic agents.

These are the cases in which the use of the drill in the canals is more called for than after removal of a recent pulp. The dentine of the pulp chamber and canal walls will be, in most cases, to a greater or less degree softened and saturated with putrid fluid. In the pulp cavity free excavation may usually with advantage always be carried out, but the dangers attending the use of the drill in root canals (referred to on a previous page) must be kept in view. Wherever a bristle carrying a few shreds of wool can be made to pass, drilling is not indispensable. Free swabbing with solution of perchloride of mercury in absolute alcohol will sterilise and render perfectly aseptic the putrid walls of the canals. Desiccation may be made more rapid and complete if the hot-air syringe be used at a high temperature such as would not be tolerated were a living pulp present. The swabbing may be repeated over and over again at intervals in cases which need it. Absolute alcohol completely abstracts water from the tissue and renders it eager to absorb the antiseptic fluid when next applied; and there can be little doubt the fluid passes into the substance of the dentine, and renders even that which is partly softened safe from putrefactive changes when shut in by stopping, and guarded from further access of external agents.

* These cases are often complicated by chronic alveolar abscess, a subject dealt with in the next chapter.

The utmost pains must be taken in manipulation not to force septic matter through the apical foramen or acute periodontitis will probably supervene. The pulp chamber being cleared may be repeatedly well swabbed with antiseptic spirit. This with the hot-air syringe will cause speedy abstraction of the moisture from the root canals. The antiseptic may then be gradually pumped into the canals. By the time the depths are approached remaining organic *débris* will have been desiccated and sterilised, and the roots may be safely explored throughout and cleared of solid particles with barbed nerve extractors.

Thorough washing out of the canals with water with the special fine-nozzled syringe made for this purpose may be practised to ensure perfect removal of all *débris* either before or after sterilisation ; but when this is once effected the use of water is better not repeated unless charged with an antiseptic. In the great majority of cases of dead pulp or "pulpless teeth" the safest practice after thorough cleansing and disinfecting in the manner described is to dress the roots antiseptically at intervals of a few days to a week or so until all danger of untoward symptoms such as periodontitis seems past ; but in some instances in which the death of the pulp has been comparatively recent and in which softening of the walls of the pulp canals is not present, permanent filling may be performed without delay. It is, however, better to exercise too much than too little caution. It is evidently preferable to dress and stop a tooth temporarily a few times rather than risk its loss by excitation of acute periodontitis. Root dressings may be composed of shreds of wool with perchloride of mercury, or with iodol or eucalyptus oil, or with these two latter combined. A few fibres of wool are lightly twisted round the non-barbed

but roughened end of a bristle, and charged with the antiseptic are carried down the root. The cotton is then detached by reversing the turn of the bristle, and shred after shred is packed in the same way. A temporary filling easy of removal is then inserted. At each dressing the canals can be treated with absolute alcohol and perchloride. It must never be forgotten that care is always necessary to prevent septic particles from being pumped through the apical foramen. The roots are subsequently filled by one or other of the methods already described.

Although perchloride of mercury is among the most powerful of antiseptics there are—it has already been remarked—a considerable number of drugs with similar properties, of which the operator has choice. Formalin is of great value in the treatment of nerve canals containing putrid pulps. It is one of the most powerful of antiseptics. A strong solution (20 per cent) may be used to wipe out canals, or to moisten shreds of cotton to act as dressings for root canals. Cleansing of foul roots may also be effected by solution of peroxide of hydrogen; the fluid being pumped by means of a bristle with wool fibres into the canals. The decomposing material is rapidly oxidised and may be syringed away.

It is necessary to bear in mind the distinction between agents like the perchloride of mercury and carbolic acid—which are true germicides—and others like eucalyptus oil and boracic acid, which cannot be relied upon to destroy micro-organic life. The first class must be used to sterilise; the second may be employed to maintain a part in the aseptic condition.*

The general principles which guide the operation of filling do not vary in insertion of permanent stoppings

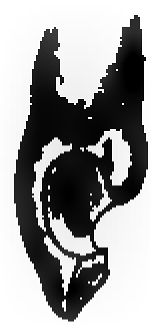
* See Appendix C.

after extirpation of the pulp and root-plugging. Some further explanation with illustration of typical examples may suffice to make the subject fully understood.

In a large number of cases in bicuspids and molars, it is found very useful to fix metal pins or posts in the root canals to support and give strength to fillings. The pins, which should be of platinum when amalgam is to be used, can be secured by thrusting their ends to sufficient depth into the cement, while soft, with which the canals are being filled, or they may be packed in with amalgam. They may be screwed into the canal mouths, and screw wire for this purpose can be kept in readiness.

FIG. 200.

A B



When fixed the wire can be cut down to the required length, and the end bent over within the cavity in a crook shape when desirable.

The pulp chamber can be filled entirely with the permanent stopping, but in most instances it is best to fill it partly with cement. To the cement, while soft, it is a good plan, in many instances, to attach the first portions of amalgam or gold, so as to form a secure foundation for the filling—a method illustrated in fig. 190, on a previous page.

A central incisor prepared for root filling and stopping is illustrated in fig. 200. A shows the posterior aspect

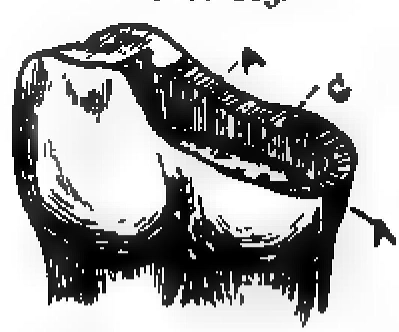
and indicates the extent to which the cavity usually needs opening to allow free access to the root canal. B gives a view from the mesial aspect, the dark patch representing the pulp chamber. Such a case might be filled with cohesive gold, or if the cavity could be formed

FIG. 201.

FIG. 202.

of a suitable shape might be restored by a porcelain inlay. When the walls of such a cavity are formed largely of thin enamel only it is often impossible to insert a metal filling. In such cases a gutta percha or cement stopping must be used; or the crown can be

FIG. 203.



excised, and a pivot tooth fixed by the method to be described in a later chapter.

Figs. 201, 202 and 203 illustrate preparation of a lower molar, in which two thirds of the crown have been destroyed by decay.

The walls, which for a contour stopping are needed to stand considerable strain must be cut back freely, and this should be done preliminary to clearing and filling the root canals. Figs. 202 and 203 show the roots filled and the cavity ready for a cohesive gold filling. A A A A are retaining points, G is an undercut groove running round the cavity and connecting the retaining points; and P, fig. 202, shows the root canals. The retaining points would not be needed for amalgam, but metal pins might be fixed into the root canals. Teeth as much broken down as in this example may be most easily, most perfectly, and most permanently restored by the operation of crowning; a process described in a later chapter. Very few operators would, now-a-days, put themselves and their patients to the fatigue and loss of time involved in the building up of a gold contour stopping in a case of this kind. Such an operation was, however, often needed (if the most perfect result were aimed at) before the invention of the "cap crown."

It will be often found expedient to fill a case of this kind with amalgam. Poor patients cannot afford gold caps. The tooth may be restored by a contour filling built up around platinum pins and supported, during setting, by a matrix; or the crown may be left truncated, the stopping being finished with a surface sloping from the lowest to the highest point of the walls.

DISEASES OF THE DENTAL PERIOSTEUM. PERIODONTITIS. ALVEOLAR ABSCESS. PERIOSTITIS AND NECROSIS OF THE MAXILLÆ. DENTAL EXOSTOSIS. NECROSIS. ABSORPTION OF ROOTS OF PERMANENT TEETH.

In entering upon the subject of disease affecting the vascular covering of the teeth—the periosteum—and the structures with which it is connected, it is desirable to bear in mind considerations similar to those advanced at the opening of the chapter on diseases of the pulp, namely—that the pathology of these parts is in its nature the same as that of all similar vascular tissues, and the principles which guide treatment are therefore alike. Modifications which are called for in treatment in consequence of anatomical peculiarities of the parts, will be noted in their proper places. It may be remembered that cement is identical in structure with bone, but when normal in development forms only a thin avascular layer. It is intimately united with the dentine which it covers. The absence of vessels within the tissue accounts for the fact that when necrosis occurs the dead tissue, although it may be gradually removed by absorption through the vessels on its surface, does not like bone become detached to form an exfoliation or a sequestrum. This instance exemplifies pathological variation due to anatomical conditions.

Dental Periostitis. Etiology.—Inflammation of the dental periosteum (sometimes termed periodontitis) may be confined to one tooth, or may involve several or all the teeth of each jaw. The former variety is that most frequently met with in dental practice, the

commonest cause being extension of inflammation from a diseased dental pulp. Periostitis also often arises after the filling of a cavity in which portions of suppurating or decomposing pulp have been improperly left, and in which septic matter not finding escape, penetrates to the depths of the root canals, reaches the periosteum and sets up irritation. Periostitis may extend from one tooth to those adjacent through the periosteum of the jaw, or may spread from the gums, inflammation of which, indeed, if at all extensive, always in some degree involves the periosteum. Periostitis may result from mechanical injuries of the teeth or alveoli, it may be caused by the continued inhalation of fumes of phosphorus, or may arise from rheumatism, syphilis or scrofula, or from cold, or from the effects of mercury upon the system (when however it is an extension from the gums), or from debility; whilst finally certain cases of general subacute or chronic periostitis, associated with absorption of the alveoli (pyorrhœa alveolaris), frequently present themselves, in which the cause can rarely be satisfactorily ascertained. Periostitis due to constitutional causes usually affects at once many or all of the teeth of one or both jaws.

Acute Periodontitis. Symptoms.—The symptoms of acute dental periostitis commence with a feeling of uneasiness in the affected tooth. In this condition the patient very often finds momentary relief by steadily biting on the affected tooth, no doubt through the emptying of the vessels which the pressure temporarily effects. The uneasiness increases in the course of a few hours into aching pain, accompanied by tenderness of the tooth, especially when pressed into the socket as in mastication. If allowed to continue these symptoms increase in intensity. The pain becomes severe, and the sensibility of the tooth extreme; and the tooth is felt evidently protruded

slightly from the alveolus, and loosened owing to swelling of the lining membrane. The neighbouring teeth become tender, the inflammation involves the gum and spreads thence to the cheek, which becomes swollen and œdematous—the œdema often extending to the palate and eyelid when an upper tooth is the centre of the disease. When lower wisdom teeth or molars are the seat of the disease, closures of the jaw, as described on an earlier page (under the heading "Impaction of Wisdom Teeth"), sometimes supervenes, and in most cases the movement of the jaw is more or less impeded by the inflammatory swelling. With these symptoms more or less febrile disturbance is associated in accordance with the extent of the inflammation and the condition of the patient's general health, The tongue is foul, the breath tainted, the skin is hot, and there are thirst and headache. At this stage suppuration takes place, pus is formed, points and finds its way to the surface of the gum, and this is followed at once by diminution of the pain and by slow subsidence of all the symptoms. The acute stage of such an attack, uninfluenced by treatment, usually lasts from three to ten days. Perfect recovery may take place; the inflammation may remain chronic; it may end in partial or complete necrosis of the tooth, or spreading to the periosteum of the jaw, may cause necrosis of bone to a greater or less extent.

Pathology.—The pathology of periodontitis is essentially the same as that of inflammation of other bone surfaces. There is first congestion, soon followed by exudation, which at the outset is composed of leucocytes and liquor sanguinis. This soon becomes replaced by pus, and as the fluid accumulates beneath the membrane the cement becomes gradually stripped. In this stage there is imminent danger that necrosis may ensue unless

the fluid find vent, and the periosteum again become attached to the cement. It is believed that in some cases, after partial destruction of the membrane, new periosteum may be formed from granulation tissue as recovery takes place.

On the extraction of a tooth the seat of acute periostitis, the periosteum in the early stage of the attack is found thickened, red and injected; later it presents on its surface patches of lymph, and when pus has formed it is not uncommon to find attached to the extremity of the fang a distinct sac containing matter. This arises from suppuration of the internal layer of the periosteum, which becomes detached from the cement, thickened and dilated, and filled with purulent matter, as just described.

Diagnosis.—In diagnosis of acute dental periostitis there is not much room for mistake. The only disease with which it is likely to be confounded is inflammation of the pulp, and the main symptoms which differentiate this having been given in the last chapter, need not be repeated here. In inflammation of the pulp the seat of trouble lies within the tooth; in periostitis it is without. In the former, general tenderness of the whole tooth to the touch does not appear until towards the end of an attack; in the latter, it begins with the onset of inflammation. The two conditions commonly co-exist, and it has already been pointed out that acute inflammation of the pulp when extensive is usually associated with at least congestion of the dental periosteum—congestion which, if neglected, often runs on to inflammation.

Treatment.—The treatment of acute periodontitis must be governed by the cause of the disease and other circumstances, and although the great majority of cases yield to active measures, the question of extraction will

sometimes arise. Teeth or roots which have been long the seat of chronic inflammation, or alveolar abscess, or which are extensively necrosed or are loose owing to absorption of their alveoli, may be often extracted without hesitation on the appearance of an attack of acute periostitis, whilst it is sometimes necessary to sacrifice a tooth to cut short an attack and avert the dangers of suppuration. In cases of closure of the jaws immediate extraction of the tooth will also be frequently called for.

If extraction be deemed desirable there need be no hesitation in performing the operation at any stage of the affection. There is an error on this subject, which not only prevails to some extent among the more intelligent classes of the public but still lingers among some practitioners of surgery. The belief is that it is both difficult and dangerous to remove a tooth when great swelling and inflammation of the soft parts are present. There are, however, no grounds whatever for such belief. A tooth the seat of acute periostitis is always loose and protruding from the socket, and there are, therefore, no special difficulties attending its extraction. No harm can possibly arise from the operation, whilst, on the contrary, in cases in which it is called for, much good must follow, since the tooth constitutes the sole cause of the mischief. Its removal is usually enough to give vent to pent-up matter, to speedily relieve pain and to put an end to all urgent symptoms. On the other hand, it must not be forgotten that to save even truncated teeth or broken-down roots may be worth much trouble to the patient; brought into a healthy state and filled, or with artificial crowns attached many roots which formerly would have been thought beyond treatment, may now be permanently preserved in a useful condition.

If it be resolved to endeavour to save the tooth, and the case is seen in the earlier stages, attention must first be directed to the pulp chamber and root canals. It will often be found, where greater part of the pulp is dead, that a small portion retains its vitality in the depths of a root—sometimes in one only of the roots of a molar—and from this portion of living tissue inflammation has extended to the periosteum. These living portions must be destroyed and removed; they always perish if the disease progress; and a living portion of pulp is very rarely found within a tooth in advanced periodontitis. Where gangrenous pulp is present and in "pulpless teeth" the canals must be cleared and brought into an aseptic condition by the methods described in earlier pages, the utmost care being exercised to avoid forcing septic matter through apical foramina. The pulp chamber and roots may then be dressed antiseptically and the orifice of the cavity of decay sealed with a temporary stopping. The dressing should consist of wool moistened with eucalyptus oil or weak solution of perchloride of mercury, and it should be loosely packed so as not to obstruct flow of discharge. Wool saturated with perchloride and dried forms a capital dressing. It is prepared in this form by manufacturers. Or a dressing with chloroform or absolute alcohol and iodol—which is easily dried on insertion by the hot-air syringe—or twenty per cent. solution of formalin may be used. The gum over the root may be painted with a mixture of equal parts of tinctures of iodine and aconite, or there may be applied capsicum plasters, such as are now prepared for this purpose.*

* These plasters are made of small pads of felt and are easily applied to the gum over the root. They act as counter-irritants. They seem to relieve pain in many cases of incipient periodontitis and to hasten suppuration when this is inevitable.

If the tooth has been previously stopped the treatment of an incipient attack of periostitis will depend somewhat on the history of the case. If the root canals have recently been antiseptically filled and a permanent stopping inserted no alarm need be excited by slight lingering congestion about the root manifested by some uneasiness or tenderness, for this very commonly occurs and it usually passes away in a few days. Capsicum plasters often seem to give relief in this condition. But if the previous history of the case is not accurately known, or if there is reason to suspect a septic condition of the pulp chamber, the stopping should be removed, and the interior of the tooth dealt with in accordance with the conditions which it presents.

If the inflammation continue in spite of this treatment, local abstraction of blood, incision through the gum to relieve tension and evacuate pus, and persistent use of hot fomentations within the mouth, are the measures called for. Although leeching sometimes seems to do good, it is commonly disappointing in its effects. A leech can be applied by means of a leech glass, but it is often not easy to make it bite near the affected tooth. An incision, short and carried well down to the bone, may be made over the apex of the root as soon as swelling appears and even before pus can be detected.

In some few cases in which marked pyrexia appears, the administration of a brisk purge may be found beneficial. For some patients an ordinary saline draught, such as a Seidlitz powder, will suffice; to others with muddy complexion, foul tongue and constipation, calomel or blue pill, with colocynth, may be administered, followed by a saline draught if necessary.

When suppuration has commenced, extra care must be taken not to obstruct flow of pus by the root canals, through which it often drains from the alveolus; and if

the flow be considerable it is often best to leave the canals empty and the tooth unplugged until the acute stage is subsiding.

Very often cases do not present themselves until the later phases of inflammation have become developed. By this time the tooth is too sensitive to allow much manipulation. If a stopping is present it may, however, usually be pierced to the pulp cavity without much pain by a sharp drill with the engine.

On subsidence of the acute symptoms, antiseptic treatment of the roots may be cautiously recommenced. Eucalyptus oil or carbolic acid or solution of hydronaphthal or of perchloride of mercury may be pumped up the root canals by means of a bristle and cotton fibres, and may be, in most cases, made to flow through the foramina into the alveolar abscess or fistulous tract when these exist. An abscess if it have not already broken, must be opened through the gum and injected or swabbed daily or at longer intervals with the same antiseptic. The opening should be made in a dependent position to encourage drainage, and if, as sometimes happens, the incision tends to heal and close before the abscess is cured it must be kept open by a strip of lint until the healing process is advanced. This is, however, rarely needed with a small abscess.

Chronic Dental Periostitis may arise from any of the causes which originate the acute form of the disease. It often remains as a result of an acute attack. Periodontitis due to constitutional causes is generally chronic, and rarely passes at all beyond the subacute stage. The symptoms comprise in a modified degree those present in acute inflammation. The teeth are tender on pressure, they are the seat of a varying amount of pain, they are more or less loosened and raised from their sockets, owing to the swelling within ; and they are surrounded

by reddened and swollen gum. On pressing the mucous membrane in some cases either pus or muco-purulent matter oozes from around the necks of the teeth, or escapes through a fistulous opening in the gum. These symptoms may continue for months or years until the teeth becoming completely loose, in consequence of absorption of the alveoli, are at last lost.

Roots, the seat of chronic inflammation, exhibit various pathological changes. The periosteum is always thickened and more or less injected, and covered with patches of lymph. A complete sac, containing pus similar to those occurring in acute inflammation, is often found attached to the apex. In the same situation there are frequently found masses of fibrous tissue—hypertrophied root membrane—which are often undergoing ossification at the point of junction with the cement. In other cases exostosis or partial necrosis exist, and absorption of cement and dentine, indicated by a rough excavated surface, are commonly observable.

Treatment.—The question of the extraction of the affected tooth will arise in many instances, and must be decided in accordance with the circumstances of the case. The condition of the carious cavity (when one exists), the degree of loosening of the tooth owing to absorption of the alveolus, and the presence of symptoms indicating necrosis or other pathological changes in the cement, will determine whether there is a fair prospect of bringing the organ into a useful condition.

The first step in the treatment will consist in removing the cause—when discoverable—of the disease. When the inflammation is associated with disease of the pulp, or morbid conditions of pulp cavity and root canals, these must be dealt with by measures already described. Sources of local irritation, such as tartar deposited upon the necks of the teeth or completely necrosed neigh-

bouring roots, must be removed. Local depletion is of considerable service, and blood may be abstracted by occasionally incising deeply with a scalpel the swollen gum occupying the spaces between the teeth. Some cases of alveolar abscess, although in some measure amenable to treatment, cannot be entirely cured. In these cases there usually exists some morbid condition, such as necrosis of the cement of the apex of the fang, which keeps up constant discharge. After treatment of an abscess and antiseptic filling of a tooth this discharge is often so slight as to be unknown to the patient, and such teeth with minute fistulous openings leading to the end of the root may remain for many years useful and without giving rise to serious pain or trouble. In other cases of a similar nature every attempt to fill a tooth permanently is followed by alveolar abscess, owing to arrest of discharge through the root canals. Some of these cases may be dealt with by drilling a fine hole through the neck of the tooth into the root canal beyond the stopping—the canal being left unfilled. This, however, allows decomposition to go on beyond the filling and leads to gradual destruction of the tooth. An attempt has lately been made in intractable cases like these to revive John Hunter's operation of replantation or transplantation. Some practitioners advocate the extraction of the tooth, removal by scraping of the diseased portion, including periosteum and end of the fang, the insertion of necessary fillings and replantation of the tooth, which, it is stated, becomes re-united to the socket. That some cases so treated have run a satisfactory course is attested by unimpeachable authorities; but it is doubtful whether in any case a tooth has after such treatment, ever remained serviceable for many weeks. Hunter had, and almost every one since Hunter who has performed the operation has had, successes of

a temporary kind; but if justification for the procedure can, in any case be admitted—a proposition to which few practitioners of experience will subscribe—it ought to be practised only as a last resource, and after failure of ordinary methods of treatment.

In periostitis due to or aggravated by constitutional causes, attention must be directed to the general health. Rheumatism, syphilis, debility and mercurialization must each receive its appropriate treatment, but this falls beyond the province of a dental surgeon.

Alveolar Abscess.—Certain phases of the suppurative stage of dental periostitis constitute the conditions most commonly spoken of under the designation of alveolar abscess; and although the separation of this subject from that of periostitis is artificial and arbitrary, some points may well be discussed under a distinct heading. This class of abscess is seen in its simplest and most familiar form in the ordinary gumboil, which consists of a collection of pus between the gum and the bone, external to the root of the tooth which is the seat of inflammation. In severer forms of dental periostitis, the cheek having become involved in the inflammation, great swelling having taken place, and suppuration to considerable extent having ensued, the matter, if it does not find a ready exit into the mouth, may point and burst through the skin externally. Thus there results a fistulous tract between the diseased tooth and the surface of the cheek, which remains open and discharging as long as inflammation continues. This termination, although it occasionally supervenes upon suppuration around other teeth, much more commonly follows alveolar abscess connected with lower molars. Suppuration in alveolar abscess always commences in the socket at the surface of the tooth, but as soon as matter forms absorption of the bone is set up and the matter

escapes into the surrounding tissues. The external alveolar plate being the thinner, is almost invariably alone perforated, and the perforation often takes place with great rapidity, a few hours sufficing for the formation of a hole in the bone of considerable size. In some chronic cases the thin alveolar plate becomes dilated and forms a bony cyst around the abscess.

Diagnosis.—Abscesses connected with diseased teeth are usually traceable without difficulty to their origin. The matter does occasionally, however, burrow through the soft tissue and appear about the palate, cheek, or jaws, in situations so unusual that the relation of the discharge to the teeth is not at first suspected. In cases of abscess about the mouth or face, the origin of which is not otherwise evident, it is therefore desirable that an examination of the teeth should be made. In most cases a loosened or necrosed tooth will be discovered, and often distinct thickening and swelling may be traced from the surface to the region of the tooth. In some instances, particularly if the pus have found free vent, the tooth may show little sign of disease, and in the absence of other cause, decayed teeth, especially those extensively filled may be suspected. Removal of a filling sometimes gives vent to pus, and establishes a diagnosis. Abscesses in connexion with the upper teeth not infrequently point at a distance in the palate. In some instances pus finds its way into the antrum and produces empyema—described in a later chapter. In the case of lower molars and wisdom teeth pus may, in rare instances, burrow deep down into the cellular tissue of the neck and require surgical treatment for its liberation.

When the matter escapes through the cheek the symptoms closely simulate necrosis of the jaw. After a time the orifice of the sinus becomes surrounded by

granulations, which often increase so as to form a papilla-like projection, and from it issues a more or less constant secretion of purulent fluid. Such a case may be distinguished from necrosis of the bone by the following circumstances:—first, there is, as a rule, but one sinus when a tooth alone is implicated, whereas when a sequestrum exists there are usually several; secondly, dead bone may be detected by the probe; and thirdly, if necrosis of bone have not taken place, the symptoms, as a rule, speedily disappear on the extraction of the tooth.

The Treatment of alveolar abscess is necessarily associated with that of dental periostitis, which has been already described. In the acute stage, incision into the swelling through the gum down to the bone and warm fomentations within the mouth, are the principal measures called for. Poultices and warm moist applications to the cheek should be avoided, as they encourage the escape of the matter through the skin. Painting the skin with tincture of iodine may assist in averting this danger. It must be remembered that although most cases either yield to treatment or subside after running a certain course, the progress of the disease may in the vast majority of cases be arrested at once by the extraction of the tooth—an operation which may be performed without hesitation when the tooth is useless owing to chronic disease or extensive decay, or when pus points beneath the skin and threatens to burst externally. This latter event will be known to be imminent when fluctuation close to the surface is recognisable, and when the skin over the pointing abscess looks dusky or livid, and feels thin, and ready to give way. If the escape of pus through the skin appears inevitable, the abscess should not be allowed to burst spontaneously, but should be opened as soon as

unequivocal symptoms of pointing appear, in order to prevent the more disfiguring cicatrix which must otherwise result in consequence of destruction of a small portion of skin. Abscesses or fistulous tracts opening through the skin must be treated by dressing or syringing with an antiseptic lotion. In cases where no dead bone exists such treatment, with the extraction of the tooth, which in these cases is always called for, rarely fails to bring about a rapid cure.

To establish a permanent cure in chronic alveolar abscess it is necessary to bring about a perfectly aseptic condition of the root canals and destroy the pus-secreting lining of the abscess. For this purpose pure carbolic acid is perhaps the best agent. The root canals can be, when needful, enlarged to some slight depth at their orifices in the pulp chamber. Carbolic acid in minute quantity can then be conveyed to the mouths of the canals, and pumped into them by means of a fine steel wire bound with a few fibres of wool. If a wire fine enough to pass to the apex be used, it is in the vast majority of cases possible with patience to cause the antiseptic to flow through the foramen, and to appear within the abscess. The abscess if large may be laid open, syringed with water, and mopped with the antiseptic. This treatment must be repeated at intervals of a few days as long as necessary. Some practitioners recommend the drilling of the root canal throughout, and enlargement of the foramen so as to facilitate passage of antiseptics; but if this be carried out the difficulty of filling the canal afterwards successfully is increased. The danger of passing some of the stopping through the foramen becomes greater—an accident sure to be followed by inflammation—or on the other hand if the root be not fully stopped the unfilled end will probably become septic. When the foramen

is enlarged either by accident or design, an attempt may be made to close it by a process which has been termed "sponge grafting." A minute fragment of fine turkey sponge of a size sufficient to plug the orifice, is sterilised and passed through the root canal to its destination. If the opening be very small it may be plugged with a fragment of gutta percha. Cases so dealt with are frequently successful. As soon as an abscess has quite disappeared, the roots may be filled antiseptically. The cavity of decay should be filled with temporary stopping unless danger of relapse seems very remote.

The cases which resist all treatment have already been referred to; and the expedient of leaving a vent-hole for chronic discharges has been described. In these cases extraction of the tooth always reveals more or less necrosis of cement. When this is of very small extent and the discharge finds full vent, teeth (as also already mentioned) may remain painless and useful for many years.

Chronic alveolar abscess sometimes assumes a cystic character. A case lately treated illustrates this form. The patient presented herself with a swelling about the size and shape of a small Spanish chestnut, which had existed many months along the external alveolar wall of the upper jaw extending from the first bicuspid to the wisdom tooth. The swelling was tense and slightly elastic, as though covered by very thin bone and fibrous tissue. The second bicuspid, being necrosed and loose, was extracted. A discharge of glairy fluid took place by the alveolus, through which a probe could be passed into the cyst. This opening soon healed and the cyst remaining unchanged it was opened and kept open by a strip of lint. The case made no progress under frequent antiseptic injections and was next packed at daily

intervals with strips of lint soaked in carbolic acid and eucalyptus oil (1 in 20). After a few dressings the cyst showed marked diminution in size, and the packing being discontinued it gradually contracted and became obliterated under frequent injection of perchloride of mercury (1 in 4,000).

Cases like this simulate disease of the antrum or jaw, but their true nature, which is also suggested by the absence of symptoms of graver disease, is to be discovered by careful examination. There is also (as in the case above described) mostly a clear history of alveolar abscess—gum boil—and the exciting cause—a diseased tooth—is usually present.

Periostitis and Necrosis of the Maxillæ.—The slight limited periostitis of the alveolus or jaw, which from the intimate relation of the parts is necessarily associated with the dental diseases just described, subsides in most cases on removal of the cause; but in some instances the inflammation continues or extends, and may terminate in suppuration, followed sometimes by necrosis, to a greater or less extent, of the bone, in consequence of detachment of the periosteum. On the other hand cases occur in which inflammation, involving both teeth and bone, originates, independently of the teeth, in the periosteum of the maxilla. This form of inflammation may be caused by injury, such as fracture of the alveoli during extraction in an unhealthy subject, or by any of those constitutional conditions which give rise also to dental periostitis, and which have been already enumerated. A form of necrosis which occurs at the period of the commencement of second dentition in children, especially such as are badly nourished, or who have been debilitated by attacks of the eruptive fevers has been styled exanthematous necrosis. The necrosis in these cases is usually confined

to the alveoli of the temporary teeth, the bone being exfoliated and thrown off together with the teeth which it supports.

The Symptoms of periostitis of the jaw resemble in an aggravated form those attending the dental disease. There are violent pain and great swelling and œdema, accompanied by fever. The occurrence of suppuration is marked by rigors, and is often attended with increase rather than diminution of pain, unless the matter, pent beneath the periosteum, find immediate vent. The skin assumes a shining, erysipelatous aspect, and pits on pressure, and after a time the abscesses point and discharge pus through openings corresponding to the position of the diseased bone, to which they lead by fistulous passages. The sinuses are similar to those described as occurring in alveolar abscess discharging through the cheek. When necrosis has supervened the rough denuded surface of bone can be felt with the probe.

In exanthematous necrosis the symptoms commence in the gum, which, with the periosteum, ulcerates and lays bare the bone. This is accompanied by a discharge of fetid pus. It gives rise to little or no pain.

Treatment.—The treatment of general periostitis of the jaw lies beyond the sphere of dental surgery. It consists of local bleeding by means of leeches, and free incisions through the gum down to the bone, with assiduous applications of warm fomentations. All sources of irritation, such as hopelessly decayed and necrosed teeth, must be removed. As soon as matter forms it must be evacuated by the bistoury. The general health will of course receive due attention.

When necrosis has supervened the treatment is directed to maintaining a free vent for the discharges, destroying their fetor by antiseptic lotions, and removing

the dead bone. In exanthematous necrosis the amelioration of the general health is the first care, locally detergent lotions are called for, but incisions or bleeding are strongly contra-indicated.

Detergent lotions may be composed of perchloride of mercury (1 in 3,000), carbolic acid (1 in 50) or of Condy's fluid, half a drachm to the ounce; or any of the antiseptics in common use; and it is a good plan not only to wash the mouth frequently with these fluids, but also to inject them by means of a syringe into the sinuses when these exist.

No attempt should be, as a rule, made to remove the dead bone until it has become detached from the living tissue, which event may not occur for many weeks or months, and will be known by the mobility of the sequestrum on examination. It is especially important that force should not be applied in extracting dead bone in the case of children, lest the rudimentary permanent teeth lying within the jaw be injured or removed in the operation.

By the time the sequestrum has become detached the orifices of the sinuses have usually become so enlarged as to allow the mass to be readily withdrawn by means of a pair of sequestrum forceps, but in some cases a few touches of the scalpel may be required to complete the operation. To avoid subsequent disfigurement the necessary incisions should be confined to within the mouth.

Dental Exostosis consists of outgrowth of new tissue from the surface of the cement, and takes the form either of prominent rounded nodules or of smooth and regular masses connected with a large portion of the root. These outgrowths are in most cases situated towards the apex of the root. The new tissue is similar in structure to ordinary cement, except that the lacunæ

are generally coarser, larger, and closer together, and that when developed in a considerable quantity it is frequently penetrated by vascular canals, which, proceeding from the exterior, give off branches throughout the mass.

FIG. 204.

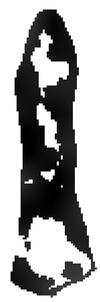


FIG. 205.

FIG. 206.

Typical examples of exostosis are shown in figs. 204, 205, 206. The bicuspid, fig. 204, displays bulbous enlargement of the deeper half of the root. In the lower molar, fig. 205, a similar condition exists. Fig. 206 shows a lower molar, the roots of which have become

FIG. 207.

FIG. 208.

elongated, and united by deposit of cement. Upper and lower molars affected with exostosis are shown in figs. 207 and 208.

The cause of exostosis is chronic periodontitis. The development of new tissue is one of the most constant

results of chronic inflammation of a low degree on cement, as on all bone surfaces. In chronic inflammation the periosteum becomes thickened and vascular, and coated with exudation. If the inflammation continue the exudation becomes organized into fibrous tissue,

FIG. 209.

which, under favouring circumstances, undergoes ossification. The new tissue is probably often deposited through the medium of the deep layer of periosteum, to which is ascribed osteogenic power. The ossification commences upon the surface of the root, and proceeds

FIG. 210.

FIG. 211.

outwards, the soft tissue becoming dense and almost cartilaginous in texture prior to impregnation with earthy matter.

It happens occasionally that roots of adjacent teeth become surrounded and united by the same inflammatory

exudation, and when this exudation becomes subsequently organized and ossified, organic union of the teeth is brought about. Adjacent lower molars thus united are shown in fig. 209, whilst figs. 210 and 211 illustrate rare examples of union consequent upon exostosis involving roots of contiguous upper molars and wisdom teeth.

The Symptoms of dental exostosis are almost identical with those of chronic periodontitis, the bony enlargement being really the result and accompaniment of the chronic inflammation. Exostosis may, however, exist after disappearance of the inflammation, without any distinct symptom being apparent, except, perhaps, slight congestion of the gum around the tooth; and teeth, the seat of hypertrophy of the cement, although they may be the seat of no pain, sometimes give rise to facial neuralgia.

Treatment.—The only available treatment is extraction, an operation which may be performed when the tooth is the cause of severe or persistent pain, or is in any way a source of constant annoyance to the patient.

Necrosis.—Teeth derive their vitality from two sources—the central pulp and the periosteum. When from any cause the pulp has been destroyed and the cement entirely denuded of periosteum, complete necrosis of the tooth results, and it is reduced to the condition of a foreign body. Complete necrosis of this kind is occasionally met with, but cases are much more common in which the necrosis is only partial. The pulp may be destroyed, whilst the connection of the cement with the periosteum remains intact; or the pulp may retain its vitality, whilst the cement has to a greater or less extent lost its connection with the periosteum.

The causes, symptoms, and treatment of gangrene of the pulp have been described in previous pages.

The cause of necrosis of cement is periodontitis, especially in its later acute phases. In these phases exudation takes place between the inner layer of the periosteum and the cement; the vessels are torn and the periosteum destroyed, and the cement being left bare necrosis ensues. Necrosis is sometimes due to absorption of the gums and alveoli, and it may arise, especially in the case of the front teeth, from an injury, such as a blow, which has partly dislocated the tooth and severed at once its vascular connections.

A tooth entirely necrosed becomes the centre of suppuration and is speedily loosened and cast off, but if the necrosis affects a small portion only of the cement, the tooth—whether the pulp be living or not—may remain useful for an indefinite time without giving rise to important pain or irritation.

Necrosis of cement manifests itself by suppuration, the amount varying, of course, with the extent of the disease. The matter escapes through a fistulous opening in the gum, or wells up round the root from within the alveolus.

The necrosed surface of roots is rough and discoloured. The roughness is due to denudation of the periosteum and to absorption, which almost always affects to some extent the necrosed cement. In cases where the periosteum is entirely detached a thin probe can be passed along the root within the alveolus to near the apex. Roots in this condition exposed to the access of saliva become coated with tartar or studded with small nodules, and the deposit is usually of the hard black variety.

The sole treatment of necrosis is extraction, but the operation is of course not called for so long as the tooth remains useful and free from severe pain.

Absorption of the Roots of Permanent Teeth is a

common accompaniment of chronic periodontitis and of necrosis. If the roots, especially the apices, of teeth affected with these diseases be examined after extraction it will be found that they often display patches of roughened excavated surface closely resembling that presented by bone and by the roots of temporary teeth when undergoing absorption. Although instances are occasionally met with, cases of complete or even of considerable absorption of the roots of permanent teeth are rare—no doubt because the teeth are usually lost before the process is far advanced. The disease, when extensive, manifests itself by loosening of the tooth. Extraction is the sole treatment.

EXTRUSION OF TEETH. PREMATURE SHEDDING OF TEETH. PYORRHŒA ALVEOLARIS. AFFECTION OF LYMPHATIC GLANDS. ORAL SEPSIS AS A CAUSE OF LOCAL AND SYSTEMIC DISEASE.

Extrusion of Teeth.—After loss of the corresponding members of the set from the other jaw with which bicuspids and molars have antagonised, it is very common for these teeth to become very slowly extruded from their sockets. The process of elongation usually occupies years, and is very often not recognised or observed by patients until the elongation of the teeth begins to render them inconvenient. Pain and inflammation are absent until the teeth, having lost greater part of their support, become strained or jarred during mastication ; and then, more or less inflammation around the end of the root may be set up. The pain and increased loosening of the tooth from the swelling within the alveolus now attract attention, and the patient applies for advice. At this stage of the affection nothing usually can be done in way of treatment except extraction of the tooth. This form of extrusion may be prevented by use of artificial teeth ; but when only very few members have been lost in an otherwise sound set, it is sometimes questionable whether the wearing of a frame attached to sound teeth, which it is sure to injure, not to speak of the discomfort it inflicts, may not be more detrimental to the patient than

the slow destruction of two or three teeth, the loss of which may cause no serious disability.

A precisely similar form of extrusion sometimes affects front teeth, particularly upper central and lateral incisors; but it occurs as often as not when the corresponding teeth of the other jaw are still in place. It is, perhaps, seen more often in women than in men, and rarely, if ever, occurs before middle age. It is impossible to assign a cause for this affection. The teeth gradually elongate through extrusion from their alveoli, which seem to fill up beneath them, the process being extremely chronic, and lasting commonly from five to ten years. The teeth at length spreading apart and overhanging the lower lip become so great a disfigurement that their extraction is called for.

Extrusion of teeth in the earlier stages may be distinguished from the disease, called pyorrhœa alveolaris—which it at this stage somewhat simulates—by the fact that it is unattended by pain and inflammation or discharge of pus from within the free edge of the gum, and it does not spread and gradually affect more and more of the set. In the final phases, the great elongation of the teeth distinguishes this malady from every other.

Premature Shedding of the Teeth.—There can be no doubt that loss of teeth, like loss of hair, occasionally occurs prematurely without existence of any recognisable morbid phenomena of an inflammatory kind. The alveoli begin to waste in middle life, or before the period when the teeth in advanced age are usually lost; and the teeth fall out one by one. These cases resemble premature baldness although they are much rarer; and they occur like baldness often in persons in robust health entirely free from constitutional disease or organic weakness.

Pyorrhœa Alveolaris.—Pyorrhœa alveolaris may be defined as a process of slow wasting of the alveoli, and gradual loosening and shedding of the teeth, attended by discharge of pus, generally small in quantity, from within the free edge of the gum and alveolus, and with deposit of tartar, mostly in form of small isolated hard nodules upon the denuded surfaces of the teeth.

The malady is extremely chronic in the majority of cases. Many months as a rule elapse before each affected tooth is shed; and from five to ten years commonly pass before the whole set is destroyed. The disease starts in one or two teeth, perhaps oftenest in lower central incisors, and gradually affects others of the set, not necessarily adjacent, until in the end all remaining teeth are involved.

Pyorrhœa alveolaris deserves to be styled the opprobrium of dental surgery. Of its etiology virtually nothing is known, knowledge of its pathology is almost equally lacking, whilst prognosis is always unfavourable, treatment being rarely able to do more than mitigate the severity of symptoms and slightly check the course of the malady. In the majority of cases in which pyorrhœa establishes itself, it slowly progresses in spite of treatment, affecting tooth after tooth until the whole dentition is destroyed.

Pyorrhœa is virtually unknown in the young; it is essentially a disease of middle and advanced age. It is not associated with caries; in a large number of cases, probably the majority, there is a singular absence of decay, and the teeth frequently are of the best structural character. It occurs in many instances in patients whose care of their teeth in the matter of cleanliness amounts to fastidiousness. In a large number of instances pyorrhœa is associated with disturbance of the general health. This disturbance is as a rule most noticeable in

sensitive patients. In this class the constant discharge of pus of noisome smell with the consciousness that their breath is tainted and its odour recognisable by others as well as by themselves, are enough alone to cause considerable depression. And no doubt the constant passage into the stomach of foul purulent discharge is likely to have an effect of its own. In cases of long standing it sometimes becomes a question whether the pyorrhœa has arisen from the lowered health, or the lowered health from the depressing effect of the local disease. Many patients date their depression from the appearance of the pyorrhœa, and in a large number of cases great improvement at once arises, and the health becomes re-established when the disease has run its course and the patient has learnt to wear and use artificial substitutes for the lost teeth. A certain number of cases are however to be observed in which pyorrhœa follows and seems ascribable to the effects of long exhausting illnesses such as typhoid fever. On the other hand careful enquiry and investigation in most cases fail to discover any organic or functional disorder capable of giving origin to the pyorrhœa.*

The symptoms of pyorrhœa begin with a spongy, slightly swollen condition of the free margins of the gums. The gums recede and their recession is often followed by deposit of tartar (ordinary salivary calculus) upon the denuded surfaces of the teeth. Slight inflammation of the peridental membrane is next soon recognisable. Swelling of the membrane raises the tooth and slightly loosens it in the socket and so pockets are formed around the tooth into which a probe passes easily to a greater or less distance along the root. From these pockets constant discharge of foul-smelling pus or muco-purulent fluid takes place. The discharge in most cases is comparatively small, pressure

* Oral Sepsis as a Cause of Disease is discussed in later paragraphs.

along the line of the gum being often needed to disclose its presence. In many cases the discharge is increased; in a few it becomes profuse.

Besides the masses of ordinary tartar which often—although by no means invariably—are deposited on the teeth there are usually to be discovered small nodules of dense consistency and dark colour scattered over the denuded surfaces within the gum pockets.

The alveoli waste more rapidly than the gum. At length each tooth becomes so loosened that the patient removes it with his fingers if it is not forced out by accidental pressure during mastication. Pain throughout the malady is slight until the tooth has become much loosened. Then a jar during mastication will often set up an attack of sub-acute or acute inflammation; and the the swelling within the socket rendering the tooth still looser, the patient will often in this condition apply for relief.

With regard to the pathology of this malady there exists one significant fact which seems to dispose of many speculations as to the real seat of the morbid process. This fact is that on the extraction of a tooth the seat of pyorrhœa, the alveolus at once assumes a healthy appearance. The discharge from that particular socket at once ceases, the gum heals in a normal manner, and if absorption of the bone continues it is not notably more rapid than under normal conditions. These facts point to the conclusion that the disease belongs essentially to the tooth and its periosteum, and that it is not due to an independent morbid condition of the investing bone.

Examination of extracted teeth yields only negative results. Nothing is to be observed on the surface of the root save the nodules of tartar already described; and it is only in the latest stages that thickening of the peri-

dental membrane the result of sub-acute inflammation is discoverable. Sometimes the apices of roots show absorption; sometimes they are covered with a soft fibrous deposit, but exostosis is extremely rare. Alveolar abscess with an opening discharging through the alveolus over the site of the apex of the roots is very rare; and only as a rule follows acute inflammation supervening on injury (a jar) to the loose tooth. Pyorrhœa has been compared pathologically to the disease of the hair termed sycosis, to which it at least bears a superficial resemblance.*

The bacteriology of pyorrhœa cannot be said to present features differentiating the disease from others associated with purulent discharge, nor does it throw any light upon the etiology. Several varieties of pyogenic cocci are usually discoverable in the pus, and, as might be expected, there are often present in the discharges a great variety of the various organisms, which, having entered from the atmosphere, are mostly to be found in greater or less number mingled with the secretions of the mouth.

The diagnosis of pyorrhœa rarely presents any difficulty. The appearances are characteristic and barely mistakeable by an experienced eye. From extrusion of teeth and premature shedding pyorrhœa is to be distinguished by the absence of inflammation in those affections. Chronic alveolar abscess may be recognised, as a rule, by the existence of caries—often absent in

* Several pages would be needed to summarize the various hypotheses which have been invented to explain the etiology and pathology of pyorrhœa; but as these are not based upon demonstrated or demonstrable facts, their value practically cannot be estimated highly. It has been for example stated, but without any verification of the statement, that the affection is really due to ulceration or caries of the alveoli progressing from their edges to the depths. Then again great importance has been ascribed to the small nodules of dark tartar which, without adequate attempt at serious proof, have been stated to contain uric acid or urates. Other statements approaching the absurd have been put forth as that the nodules are deposited from the serum of the blood, etc., etc.

pyorrhœa—and by the opening through the gum over the apex of the tooth, whilst the spongy gum and the "pouching" around the tooth are not observable. When two or three front teeth only are affected, the onset of pyorrhœa is more closely simulated sometimes by the chronic results of concussion or partial dislocation of teeth, described in a later chapter. But in these cases there is the history of previous injury; often the pulps are dead, and the discharge of pus, if there be any, is like that which occurs in alveolar abscess, not like the characteristic oozing from the spongy gums of pyorrhœa.

The treatment of pyorrhœa must be first directed to thorough removal of tartar.* General antisepsis of the mouth must be assiduously practised by the patient. A soft toothbrush and a suitable dentifrice and antiseptic lotions must be used.† The spaces between the teeth, which become widened as the alveoli waste, should be frequently cleared of foreign particles with a thin quill tooth-pick. In using a lotion the mouth should be partly filled and the fluid forced to and fro between the teeth by the movement of the lips. More direct applications must be made to the necks of the teeth and within the gum pockets around. An aqueous solution of perchloride of mercury, 1 in 3,000, is one of the most efficacious agents, but others may be, of course, employed. The perchloride solution is best applied on tiny twisted ropes of absorbent cotton. The mouth having been thoroughly rinsed, or better the pockets around the teeth syringed, access of saliva can be prevented by a folded napkin and the small ropes of wool saturated with antiseptic can be packed by a small blunt probe around the teeth within the gum pockets and allowed to remain for a few minutes.

* See chapter on "Salivary Calculus."

† See Appendix C. Antisepsis in Dental Surgery.

This can be repeated again and again, care being taken, when a poisonous agent is being used, to make the patient rinse the mouth freely each time the napkin is removed. A great variety of antiseptics have been tried in the treatment of this disease, but probably none can be more efficacious than perchloride of mercury.

Carbolic acid diluted with eucalyptus oil to a strength of one in twenty may be used, care being taken to apply the cotton ropes slightly moist only, so as to avoid excoriation of the gums. Sulphate of copper in strong solution or applied in powder to the gum pouches is relied upon by some practitioners; others use permanganate of potash (Condy's fluid). With Condy's fluid good effects are produced. It has the advantage of being practically non-poisonous, and can be entrusted in full strength to the personal use of the patient.

In some cases the patient may be trusted to make the direct application of a strong antiseptic to his own teeth; but in most cases, if the treatment is to be of great service, he must pay frequent visits to the dentist. The assiduous employment of antiseptic lotions by the patient with scaling and occasional more vigorous treatment by the dentist are usually enough to mitigate the worst symptoms, and to prevent the patient suffering severely from the remoter effects upon the general health, which this disease, and especially the constant passage into the stomach of fetid pus are undoubtedly capable of exciting.

Teeth which have become so loose as to be constant sources of irritation should be extracted. This improves the condition of the mouth generally, and often seems to retard the progress of the disease; but extraction of affected teeth, even in an early stage of pyorrhœa, does not put an end to the progress of the disease, nor do more than temporarily check its advance. When

numerous teeth have been lost, great comfort will often be afforded by the adaptation of a perfectly-fitting frame of vulcanite to embrace the necks of the remaining teeth, and to hold artificial substitutes in the vacant places. The frames, which for the upper jaw should be on the "suction" plan, must closely surround the teeth without causing any strain upon them. It is well patients should begin to wear artificial teeth before a late stage of the disease; so that when the end comes, and all the teeth are lost, they may have acquired the facility to use artificial substitutes which is usually attained only by considerable practice.

Affections of Lymphatic Glands.—Nothing is more common than temporary enlargement of the lymphatic glands which drain a part, the seat of inflammation and suppuration; and it might be expected that this effect would frequently be produced in connection with the inflammatory sequels of caries. The sub-maxillary glands are those most likely to be affected by dental disease. These glands drain the lymphatic system from the floor of the mouth, the gums and alveolar processes, and the front part of the tongue. Glands at the posterior angle of the jaw drain the back part of the tongue and tonsils, whilst a deeper set drain from the pharynx and naso-pharynx. In adult patients enlargement of lymphatic glands is, however, not a common accompaniment of alveolar abscess or dental necrosis; but does occasionally occur. When enlargement of glands in the sub-maxillary region exists the teeth should always be carefully examined; and it must be recollected that a root may be the seat only of a minute patch of cement necrosis giving rise to a mere trace of suppuration, but yet enough to infect neighbouring glands. In adult patients, unless all such local conditions are dealt with, it is impossible to be certain that the sole cause or a

contributory cause of a chronic glandular enlargement has not been neglected. In children and in youthful subjects the necessity for removal of dental disease, which may be a cause of glandular affection is imperative. This subject has been recently explained, and the work of observers besides himself summarised by Mr. Watson Cheyne.* It has been established that the onset of tuberculosis of the cervical glands is often associated with local inflammatory conditions, and among these carious teeth are the most common. The fact has not been perhaps completely demonstrated, but the evidence is strong that the tuberculous bacilli may enter the tissues around the roots of teeth the seat of abscess, and may be carried to the glands, and set up disease there. Tubercle bacilli have been found in connection with carious teeth. Out of six cases investigated by one observer tubercle bacilli were present in the tissues around in three.

In presence of this danger, it may be laid down as a general rule to which no exception can be allowed, that in every case in which a tendency to glandular enlargement in the neck appears in early life the teeth ought to be carefully examined; and all those teeth should be extracted which cannot be brought into a healthy condition—a condition in which inflammation of the pulp and periosteum with their sequels do not exist.

Oral Sepsis as a Cause of Local and Systemic Disease. —Advance of the science of bacteriology within recent years has led to more attention being given to septic conditions of the mouth as factors in causation of disease. That the mouth forms not only a receptacle, but an abiding and propagating-place for many species of

* Harveian Lectures on Tuberculous Diseases, 1900.

pyogenic and pathogenic organisms was mentioned in the chapter on the etiology of caries. The organisms mingle with the secretions, lodge in the interstices of the teeth, or within carious cavities, and attach themselves to the mucous membrane. They accumulate in alveolar abscesses, in the pockets formed in the gums around the teeth in pyorrhœa alveolaris and in similar situations. In these situations various pathogenic bacteria are often to be discovered; and it is believed that in this way, when the patient is in a susceptible condition, there may be conveyed into the system the specific toxins of diseases, like diphtheria, typhoid fever, and tuberculosis. These facts serve to emphasize the importance of general hygiene of the mouth, and the necessity of maintaining cleanliness and preventing conditions favourable to the proliferation of any species of organism.

With regard to the effects upon the system of the constant passage into the stomach of foul, purulent secretions, poured out in various dental diseases, observations by numerous authorities have lately been published. Mr. Rickman J. Godlee* has particularly dealt with the medical and surgical complications of pyorrhœa alveolaris. He directs attention to the fact that the disease often exists without the patient or the medical attendants being aware—very little evidence of it being apparent to casual examination. He relates cases in some of which the discharge was profuse, as much as from five to six ounces being hawked up from the back of the throat in twenty-four hours. Mr. Godlee describes the effects upon the health, such as indigestion and mental depression, traceable to this disease; and in the improvement, which treatment of the pyorrhœa alone brought about, he finds proof that the

* Med. Chir. Trans., Vol. lxxxiii., 1900.

local malady was the cause of the illness. He relates a case of a patient, aged sixty-six, the subject of advanced pyorrhœa, who was seized with acute glossitis and stomatitis with profuse salivation and formation of ulcers on the tongue and lips. No other cause being discoverable these effects were ascribed to the pyorrhœa. Extraction of hopelessly loose teeth and vigorous treatment of the gums were followed by immediate improvement; but the ulcers on the tongue were slow in healing. Mr. Godlee adds a case observed by Dr. Sidney Martin (in University College Hospital), in which the symptoms of carcinoma of the stomach—severe pain after food, frequent vomiting, great loss of flesh, and increasing "sallowness" of complexion—were caused by the constant swallowing of pyorrhœal discharges. All the symptoms disappeared rapidly with treatment of the teeth.

Dr. William Hunter* in a lengthy communication gives an account of a great number of local and systemic diseases, to which he ascribes oral sepsis as the sole cause, or as a factor in causation. Besides enlargement of the lymphathic glands (already described on a previous page), Dr. Hunter enumerates among local affections inflammation of tonsils, pharynx, and ears. He points out that there is constant presence of pathogenic bacteria to a greater or less degree in many, if not most mouths; and that the question of effect in any one case is a matter of individual resistance. Dr. Hunter believes the effects he has mentioned are very common; that they are not even more common is due to the remarkably resistant powers possessed by the mucosa of the mouth. He points out how rapidly wounds in the mouth heal, although the sepsis connected with the diseased teeth is of a particularly virulent character, much more so than

* Practitioner, December, 1900.

the pus derived from soft tissues. It is really connected with disease of bone (cement); and a somewhat extensive pathological experience of its effects, both professional and in *post-mortem* work, has satisfied him that no pus organisms are so virulent as those grown in connection with necrosing bone.

Dr. Hunter gives the following among many cases to illustrate how slight the local condition may be, and yet how marked its effects on the individual:—

CASE 5.—General symptoms: salivation, gastric, discomfort, gastric catarrh. Oral condition: localised gingivitis beneath a gold bridge, which stretched between two gold caps. Immediate disappearance of symptoms on removing bridge and gold caps. A small pocket was found beneath the bridge filled with pus organisms.

CASE 6.—General symptoms: salivation and gastric discomfort, gastric catarrh. Oral condition: local gingivitis, in connection with a gold cap covering a crown. On removal of cap, its lower edge was found to cover a small carious cavity in the neck of the tooth. This case was in the same individual as the previous one. The symptoms disappeared on removal of the cap.

Dr. Hunter remarks, "Cases similar to the above could be multiplied indefinitely. In every out-patient department of every hospital one can see them daily. The condition is so marked that one has only to look into the mouth of such patients to see what is the trouble."

Dr. Hunter dwells upon the toxic effects due to absorption arising from oral sepsis and enumerates the following diseases which he states he has met with, ascribable to this cause:—

(*a*) Fever—of obscure character—really septic.

(*b*) Septic rashes.

(*c*) Purpuric hæmorrhages and bleeding from the gums, such as are so often found preceding ulcerative endocarditis.
(*d*) Profound septicœmia.
(*e*) Lastly, a group to which his studies in connection with pernicious anæmia have recently specially drawn his attention—namely, nervous effects, denoting deeper-seated changes in the nervous system; effects which he would include under the title of Toxic Neuritis.

Full discussion of the subject of oral sepsis in relation with systemic disease is beyond the scope of this manual. Dental surgery is concerned alone with pathological conditions within and around the teeth, and it is beyond the province of a dentist to diagnose or treat any save dental diseases, and the effects closely associated with them. It however often becomes the serious duty of the dental practitioner to direct the attention of a patient or his medical adviser to septic conditions of the mouth likely to give rise to, if not actually the cause of, remoter local affections or systemic disease. Among the commoner local affections, enlargement of cervical glands due to diseased teeth has already been mentioned; and the effects of pyorrhœa alveolaris upon the general health have also been referred to.

The local treatment of oral sepsis consists in the extraction of hopelessly diseased teeth, and the removal of all sources of suppuration of dental origin. Salivary tartar must, of course, be cleared away; and the assiduous use of the tooth brush and tooth pick, together with tooth powder and antiseptic lotions (as prescribed in the chapter on "Prevention of Caries") must be insisted upon.

CARIES AND ITS SEQUELS IN INFANCY AND EARLY CHILDHOOD.

NEITHER in regard to etiology, pathology, nor diagnosis do diseases of the temporary teeth differ materially from those of the permanent set, but there are some special points with respect to treatment which call for separate notice. The preservation of the temporary teeth until the period at which they should be naturally shed is important. They are needed for the performance of their function—mastication. If allowed to decay they give rise to suffering detrimental to health, especially in delicate children. Their premature removal, as already pointed out, is a frequent cause of irregularity of their successors.

Temporary teeth are very frequently affected by caries. As a preventive measure cleanliness cannot be practised too early. From the first until a child is old enough to do it for itself its teeth should be cleaned at least once a day. To rub the incisors with a wet cloth may suffice at first, but as soon as the temporary set is complete and the child is old enough to bear it without difficulty, a soft tooth brush may be used at least once in the twenty-four hours—preferably after the last evening meal—so as to remove particles of food which may have accumulated during the day. The use of tooth powder, and antiseptic lotions when needed may be begun as

soon as the child is old enough to rinse its mouth. A child that has been taught this regimen as a part of daily hygiene will not be likely to omit it in later life.*

Carious cavities in temporary teeth should be filled without delay. When the dentine is but slightly penetrated the pain of the operation is usually very slight and not sufficient to discompose the average infant. Enamel chisels and excavators are as a rule only needed; the use of the dental engine should be avoided as terrifying if not painful.

The object being only to preserve the teeth for a comparatively short period, no purpose is served by putting in fillings of great durability. In preparing the cavity the main point is to ensure a sound external margin and to cut away diseased tissue at the orifice to such an extent only as to ensure arrest of decay. It is best to leave in the depths all dentine except such as is disorganised and in the last stage of softening. Sealed under a stopping of suitable kind, dentine in this state —the removal of which would expose the pulp and probably lead to loss of the tooth—gives rise to no evil consequence. Cavities which do not penetrate deeply are best filled with amalgam. An amalgam which can be used in a soft state should be chosen to avoid much pressure in packing it; and to express excess of mercury, when necessary, a pellet of cotton wool should be used beneath the plugger as described in the chapter on filling. Copper amalgam answers well in many instances.

In deep cavities non-conducting fillings are preferable to metal. Jacob's gutta percha and cements are the best. In deep cavities where the pulp is nearly exposed the first portion of the filling may be commenced with a

* See chapter on Prevention of Caries.

loose pellet of absorbent cotton saturated with a thin semi-fluid mixture of cement; this being gently packed over the floor of the cavity the filling may be completed with the same cement in the usual way. When decay closely approaches the pulp great caution must be exercised; for if septic material has reached it, or if diseased, a pulp will probably become at once acutely inflamed on insertion of a filling. Where doubt exists it is well to dress the cavity for a period at intervals of a few days to a week. The dressing may be composed of wool with eucalyptus oil and iodol, or wool moist (not wet) with carbolic acid or oil of cloves and sealed with a plug, either of wool saturated with mastic cement or with gutta percha.

In exposure of the pulp, if the period has nearly arrived when the tooth should be shed, the question of extraction for relief of pain may be considered, and of course if the tooth be loose or if other indications of the imminence of the eruption of its successor be present, there need be little hesitation in removing it. Roots of temporary teeth are no sooner fully formed than they commence to become absorbed, and therefore there is during most of the period of their existence very free communication between the pulp chamber and the alveolus. For this reason inflammation may quickly extend from the pulp to the periosteum and socket. Attempts to destroy the pulps of temporary teeth by arsenic during the shedding period when a large orifice caused by absorption exists at the apex of the root give rise in the majority of cases to immediate acute dental periostitis. The only favourable cases for this treatment are those in which it is possible to be tolerably certain that the teeth are at that epoch of their existence—a very brief period—when the roots are not in process either of formation or absorption, and when the apical

foramina are at their smallest size. In such cases destruction of the pulp by arsenic may often be successfully performed. The difficulties of capping the pulp in temporary teeth are too great to warrant the attempt. For the relief of pain careful excavation of the cavity and applications of dressings—oil of cloves, or eucalyptus oil with iodol—under the usual temporary stopping, should be carried out. Carbolic acid repeatedly applied at intervals of days in the same way will in time destroy the pulp. In using escharotics, like carbolic acid, care must be taken to prevent them flowing on to the gum—a small pellet wet with a fraction of a drop sealed within the tooth may suffice if applied actually to the pulp on each occasion. After destruction of the pulp temporary teeth may in many cases be best left unfilled. If filling be performed the roots should be little interfered with, and no attempt to clear the depths of the canals should be made. The pulp chamber may be filled antiseptically and the cavity of decay with gutta percha or cement. A minute hole may then be drilled through the neck of the tooth into the pulp chamber as a vent for discharges. Teeth treated in this way will ofter remain useful and comfortable for the short time during which their preservation is desirable. Alveolar abscess must be treated by opening of the cavity of decay so as to give free vent to discharge; while this is ensured pain does not commonly supervene. On subsidence of the acute symptoms the teeth are in many cases best left unfilled. Necrosis, manifested by loosening and discoloration of the tooth and persistent suppuration, may call for extraction. In neglected mouths there are often found remains of necrosed roots of temporary teeth lying around or wedged between the permanent set. Sometimes, through ulceration of the gum and external

alveolar wall, following alveolar abscess, apices of necrosed roots protrude, and by chafing cause ulceration of the mucous membrane of the cheek or lip. This in unhealthy unclean children may become extensive. A case of this kind frequently looks at the first glance like a case of extensive necrosis of the jaw. Careful examination reveals the fact that the necrosed fragments are merely tooth roots. The roots, which are always loose, must be extracted. Antiseptic lotions and attention to the general health, where called for, must then be prescribed.

The first molars are as a rule the most delicate of the permanent set, and are by far the most frequently in this set the seat of easily recognisable structural defects. They are very frequently affected by caries. The disease in numerous instances begins apparently as soon as the crowns are exposed to the fluids of the mouth. Where the enamel and dentine are ill-made throughout and progress of the disease is favoured by vitiation of the buccal secretions, such as exists in unhealthy or improperly-fed children, caries runs a very rapid course. Especially in children of families with a bad dental history, these teeth need therefore closely watching from he first. Appearing early at the end of the jaw and not succeeding temporary teeth, they are commonly mistaken by parents for temporary teeth and allowed to fall into hopeless decay.

The considerations which govern the treatment of caries and its sequels in temporary teeth apply almost entirely during early childhood to the teeth under notice. Amalgam forms the best filling for simple cavities not closely approaching the pulp; for the latter class, cements, or fillings of that kind are to be preferred. In many cases the intention will have been formed soon after the appearance of these teeth to extract them, in

order to cure irregularity or relieve crowding at the proper time, *i.e.*, when the second molars shall be in place; but in cases where, as very often happens, the permanent preservation of the teeth is resolved upon, more perfect and durable stoppings may be in due course inserted. Children bear prolonged operations as a rule badly; besides which, application of the rubber dam and the various necessary procedures in gold filling inflict disquieting discomfort, if not pain; and in most cases, therefore, fillings capable of rapid, painless insertion should be temporarily employed. The treatment of exposure of the pulp, particularly in ill-calcified teeth where caries has attacked early and progressed rapidly, is in many instances unsatisfactory. Capping does not as a rule answer, and destruction of the pulp by arsenic is contra-indicated because of the largeness of the apical foramina. These very often remain patent for some years after complete eruption of a tooth. In these cases palliative measures and gradual destruction of the pulp by carbolic acid as used in similar conditions of the temporary teeth may be practised. If the teeth are of moderately good structure, have been the seat of caries progressing with comparative slowness, and have been in place for considerable time so that it is probable the roots are fully formed, destruction of the pulp by arsenic may be practised with fair prospect of success. If they are to be sacrificed later, which must be mostly necessary under the circumstances, the teeth may be dealt with and filled after the method recommended for temporary teeth under like conditions.

The chief danger to be guarded against is periodontitis, which if set up in these cases is apt to run an extremely acute course ending in suppuration. The pulp chamber and nerve canals must be cautiously

cleared of their contents. If sensibility continues in the depths, owing to existence of living portions of pulp, these must be treated with carbolic acid. Arsenic must not be applied deeply in the root canals lest periostal inflammation be excited. After thorough antiseptic treatment the pulp chamber and canals may be filled with wool saturated with an antiseptic, as described in a previous section. The filling may be completed with gutta percha or cement. Teeth treated in this way, when antiseptic conditions are assured, will often remain for the short time they are needed without untoward symptoms. If inflammation of remaining shreds of pulp do supervene, it very often gives rise to little pain, there being free vent for exudation into the cotton filling; aud, if it becomes severe, relief may in most cases be afforded by providing drainage by means of a perforation through the stopping or the neck of the tooth.

If these teeth—decayed, broken-down as they may be—can be kept free from inflammation and pain and retained by any means until the second molars are in place, the benefit accruing will often repay for the trouble expended; but many delicate children cannot bear the pain and fatigue of treatment, and in such cases teeth which might otherwise be saved must frequently be sacrificed for the immediately relief of suffering.

The presence of teeth, particularly in the lower jaw, the seat of chronic inflammation of the pulp and periodontitis, with its sequels, alveolar abscess and necrosis, forms often the sole cause or a contributory cause of enlargement of lymphatic glands below the jaw or lower down the neck. This subject was discussed in the last chapter under a separate heading, and the importance of extracting hopelessly decayed teeth to remove possible causes of affection of the glands was

dwelt upon. When tendency to glandular enlargement shows itself careful inspection of the teeth should be made; and it must be recollected that the pus from a minute speck of necrosed cement may suffice to infect the neighbouring glands. In some cases it may be better to extract suspected teeth rather than incur a serious danger.

To fill with gold teeth which will surely need extraction after lapse of a few years is evidently labour thrown away; but in some children where the jaws are not crowded and the teeth are of good general structure —particularly in robust patients who bear operations well—it may be expedient to use gold at once. Decay in permanent incisors and canines usually occuring in interstitial positions, very often shows itself speedily after eruption in delicate sets. In a vast majority of such cases the teeth are best kept filled with cement for a few years; with watchfulness to guard against failure of the stopping. In later childhood gold fillings may be inserted—a thin film of cement being left to coat the floor when the cavity is of sufficient depth.

DISEASES OF THE GUMS AND BUCCAL MUCOUS MEMBRANE. RANULA. GLOSITIS.

Inflammation of the Gums.—Inflammation of the gums may be due to various causes. Some amount always accompanies dental periostitis, and reference has been made to this variety in previous chapters. It may arise from irritation of tartar accumulated around the necks of the teeth, or from the presence of necrosed teeth and roots; it may be associated with disorders of the digestive organs, especially such as occur in pregnancy and in gouty subjects, and in those who habitually take alcohol to excess. It is sometimes, although rarely caused by constitutional syphilis, sometimes by rheumatism; it forms a prominent symptom in ptyalism and in chronic mercurialization, and it is present in some diseases which, like scurvy, are due to a depraved state of the blood. Cases of mercurial ptyalism are now-a-days very rarely met with, administration of the drug not being pushed as was the custom formerly. If cases occur they are mostly in individuals who, owing to an idiosyncrasy have displayed great susceptibility to the poison.

The inflammation may involve a small part only of the gum or may attack the whole surface in each jaw. The limited variety is most commonly occasioned by local irritation; general inflammation of the gums usually arises from constitutional disorder.

Symptoms.—The gums are deep red or purple in colour, swollen, spongy, and tender, and they bleed on

the slightest touch. Pus oozes or can be squeezed from around the teeth at the free edge of the gum, where ulceration also often occurs. If the disease continue for any length of time it always spreads to the dental periosteum, rendering the teeth loose and tender, and leading to absorption of the alveoli. Chronic inflammation sometimes leads to hypertrophy of the gum. The outgrowth is at first soft, but after the lapse of time may become hard and fibrous in character.

Treatment.—The treatment of localised inflammation around teeth in the sequels of caries and in pyorrhœa alveolaris, has been described in previous pages. In all cases of inflammation of the gums treatment must be first directed to the removal of the exciting cause; all sources of local irritation must be done away with, tartar, and hopelessly loose and necrosed teeth being at once removed. The gums in some few instances may be unloaded by free saccarification, followed by warm fomentation, in the acute stage, and by astringents, such as tannin, in the chronic form. Local bleeding must not be practised in scurvy. Where a fetid discharge exists detergent lotions may be prescribed, and the necks of the teeth may be swabbed with solutions of chloride of zinc or carbolic acid. Where the inflammation is associated with constitutional disorder local treatment is of secondary importance, and the remedies must be applied to the amelioration of the general health. The treatment of syphilis or rheumatism or the effects of mercury is of course beyond the province of a dentist.

Hypertrophy of the Gums.—This very uncommon malady sometimes results from chronic inflammation, but in many cases the causation is obscure. It is rare in the adult, mostly occurring in childhood, sometimes apparently associated with the scrofulous diathesis and also with some forms of idiotcy. The hypertrophy

generally extends along the whole alveolar border and often involves the submucous tissue, and may develop to such a degree as to almost conceal the teeth. Microscopically the growth is found to consist of a true hypertrophy of the gum, the fibrous portion being chiefly represented. On examination a mass of interlacing fibres is found embracing glandular tissue in its stroma. The surface of the growth is frequently covered with large vascular papillæ.

The treatment consists in attention to the general health, removal of all local sources of irritation, and the use of antiseptic and astringent lotions. In severe cases it is sometimes found necessary to excise the hypertrophied mass and also to remove the bone of the alveolar border whence the growth springs.

Thrush is a variety of parasitic stomatitis, an inflammation of the mouth, associated with growth on the mucous membrane of *Oïdium albicans*, commonly occurring in infants, more rarely in adults the subjects of debility. The mucous membrane is reddened and studded at parts with vesicles, especially inside the lips and on the tip of the tongue. These vesicles give place to patches of exudation, which are thrown off, leaving the membrane exposed, ulcerated, and deeply red in colour beneath. With these symptoms there is fever and often diarrhœa. The treatment must be directed to the general health. Locally, soothing applications, such as lotions of glycerine or borax and honey, are most useful.

Aphthous, or Follicular Ulceration, occurs both in adults and in children. The first stage the malady takes the form of simple inflammation of the mucous membrane. In the next stage, small, round, transparent vesicles appear, which burst, leaving small spreading ulcers with red and swollen margins. In this disease as

in thrush, in some cases, the ulcers become coated with a layer of a microscopical parasite (*Oïdium albicans*) Besides constitutional treatment, which is of the first importance in this affection, the ulcers may be touched with sulphate of copper or nitrate of silver, and a lotion may be prescribed to destroy the vegetable parasite composed of sulphate of soda one drachm to the ounce.

Ulcers of the Tongue and Lips often originate from friction against the ragged edges of broken and decayed teeth, and ulcers in these situations arising from other causes—such as syphilis and dyspepsia—are frequently aggravated by similar irritation. Ulcers due to irritation of ragged teeth vary in size with the length of time they have existed, and they may attain large dimensions. They are of irregular form, with slightly hardened bases, and are situated, as a rule, on the surface of mucous membrane lying against the faulty tooth, those on the tongue appearing on the side and under surface. These ulcers, when neglected, may assume an aspect closely simulating epithelioma, and the resemblance is rendered more complete, in some cases, by induration of glands beneath the jaw, which accompanies them.

Two such cases may be briefly narrated. The first was that of a woman, aged sixty, who was sent into the West London Hospital with a tentative diagnosis of "cancer" of the tongue. The tongue had become gradually swollen with increasing pain on movement. Food was taken with difficulty, and on admission she could swallow only fluids; there was discharge of muco-pus with some blood, the glands under the jaw on the right side were enlarged; her general aspect simulated the cachexia of malignant disease. Examination under chloroform revealed the presence in the right lower jaw of the broken down necrosed remains of molars and bicuspids, the seat of alveolar abscesses. The ragged

edges of these teeth had cut a deep excavated ulcer on the under surface of the tongue, in the tissues of which they lay buried. These teeth were at once extracted. The pain and all the symptons were immediately relieved, and the patient was discharged cured within a few days, no treatment save an antiseptic lotion having been prescribed. In the second case, that of an elderly surgeon, from the North of England, the symptoms closely resembled those of the first; but in this instance the tongue was affected on both sides, and all the teeth were perfectly free from caries. It was a case of extremely "under-hung" bite. The back teeth were worn away on their opposing aspects and their margins at many points reduced to sharp jagged edges. The tongue was naturally large, and on closure of the jaws it became caught and pinched between the opposing teeth. This seemed to take place during sleep. The sides of the tongue were deeply indented and ulcerated. In this case the patient believed himself to be subject of cancer, especially as the glands at both sides beneath the jaw were affected. All the symptoms in this case passed away rapidly after the grinding down, rounding, and polishing of the sharp, jagged tooth edges.

One of the commonest symptoms of constitutional syphilis is the occurence of ulceration of the mucous membrane of the mouth, which assumes various forms, sometimes not easily distinguishable in appearance from the varieties above described, due to other causes. Such cases can be diagnosed by their history, the presence of other symptoms indicative of syphilis, and by their obstinacy under any but specific treatment.

Treatment.—In all cases of ulcers in the neighbourhood of decayed teeth it is desirable to file down and polish rough and ragged surfaces. Should the ulcer be of a simple character it will then soon heal. The cure

may be hastened by painting the surface with a lotion, such as nitrate of silver, two grains to the ounce of distilled water.

Cancrum Oris.—This comparatively rare disease is confined entirely to young ill-fed children inhabiting low crowded neighbourhoods. The disease may be well defined as sloughing phagedæna of the gums and cheeks. The ulceration may, in some cases, have its origin in the condition described on a previous page* the condition in which a number of necrosed temporary teeth are found the seat of chronic abscesses opening through the alveolar walls, and exposing the roots externally. The partly absorbed ragged edges of such roots often cause, by friction, ulceration of the contiguous mucous membrane of the cheek; and under favouring septic circumstances the ulceration may assume a virulent form. It may begin at any part of the mucous membrane, but in many cases makes its appearance at the edge of the gum about the necks of the central incisors, in the form of a yellowish or ash-coloured ulcer. Thence it spreads with great rapidity and speedily attacks the inside of the cheek, which is, however, often swollen, and the seat of ulceration from the first. The ulceration extends in the direction of the sockets of the teeth, destroying the gums and periosteum, and causing necrosis of the teeth and bone. The affected soft parts slough, and a large ragged ulcer of a dirty blackish appearance is formed, which sometimes perforates the cheek. A profuse discharge of fetid purulent fluid and saliva accompanies the progress of the ulceration. In the early stages, and until sloughing has commenced, there is little or no pain. The disease often ends fatally, the patient dying from exhaustion.

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* See chapter on Caries and its Sequels in Infancy.

The Treatment consists in supporting the patient's strength by nourishment, together with quinine, ammonia, and brandy. Locally, the sloughing surface must be destroyed by nitric acid or acid nitrate of mercury, whilst detergent lotions are employed to destroy the fetor of the discharges.

Except in differentiating forms of stomatitis and ulcerations about the mouth and tongue from diseases connected with the teeth, these affections, in the question of diagnosis, do not come into relation with the practice of dental surgery; whilst as regards treatment the dentist's function is confined to removal of causes of irritation such as ragged edges of teeth, which may tend to aggravate the mischief. The simple ulcer due to this latter cause always gets well rapidly on removal of the irritation; and so confirms the diagnosis. Ulcers which remain obstinate after this treatment do not fall within the range of dental surgery.

Ranula.—The term Ranula was applied by some writers strictly to the one kind of cystic tumour occurring on the under surface of the tongue, and caused by obstruction of the duct of the small mucous gland—the so-called Blandin-Nuhn gland. The most recent authoritative description of the varieties of ranula is that published by Messrs. Butlin and Spencer.*

These observers point out that the name ranula has proved the source of much unnecessary confusion. Many totally different conditions have been included under it. If the word is used it should be applied to any obstruction of the mucous and salivary glands under the tongue. The different forms of ranula will then

* Diseases of the Tongue, second edition, 1900.

correspond to the glands, submaxillary, sublingual, Blandins, and the incisive gland, and will vary according as the obstruction is acute, intermittent or chronic, and according to the direction in which the cyst tends to bulge.

The causes of ranula are inflammation within the ducts, giving rise to plugs of inspissated mucus in which calcareous matter may be deposited—probably microbic in origin. No connection has been noticed between ranula and inflammatory conditions of the mouth or carious teeth. Foreign bodies in ducts have been seldom demonstrated. Ranula may be congenital; cysts of new formation are not generally held to be ranula.

Sublingual ranula is the commonest form. It forms a painless swelling in the floor of mouth between the tongue and jaw, and has a translucent appearance with large veins on the surface; it is tense, fluctuating, and does not pit on pressure.

In ranula of Blandins gland the tongue can be protruded with cyst attached beneath, leaving the floor of the mouth free. This form may be congenital. On incision fluid like egg-white escapes.

In ranula of the submaxillary salivary gland, the duct and intrabuccal portions of the gland may be affected; the external portion of the gland may become cystic and bulge below the angle of the jaw. This gland is the common seat of calculus. Ranula here may be acute, intermittent, or chronic. The acute form may be attended by severe pain.

Treatment.—A calculus obstructing a duct may be usually with ease pressed out of its position with an instrument or the finger nail; sometimes a touch with a scalpel may be needed. A small ranula will usually disappear after being opened and having its contents

pressed out. If the opening tends to close and the cyst to refill, or if the ranula be large, a small piece may be snipped out with scissors. Sometimes besides these measures the inner surface of the cyst will need acting upon. This may be done by scraping gently the interior with a rough-ended probe or by mopping out the cyst occasionally with solution of nitrate of silver, four grains to the ounce, or chloride of zinc, five grains to the ounce, by means of a small probe bound at the end with a few filaments of cotton wool. Sometimes a large ranula will call for complete excision. The treatment of ranula lies outside the range of dental surgery.

Glossitis.—This term is sometimes employed to distinguish inflammation of the tongue extending below the surface. It may be either acute or chronic, and the cause is very often difficult to discover. The symptoms are tenderness, pain, and swelling, and often increased flow of saliva. Movement of the tongue is impeded, and in the later stages breathing may be interfered with. The symptoms may advance in severity until, pus having formed and an abscess having burst, they gradually subside. A case was seen by Mr. Sewill which went on to formation of a deep abscess, and which in the early stage was mistaken for dental periostitis, diseased roots being present to which the patient pointed as the seat of pain. Such a mistake ought not to occur if careful examination were made.

The treatment includes application of ice, which answers better than hot fomentations in these cases, to diminish swelling. As soon as pus has been formed or before, in order to diminish swelling or relieve tension, an incision may be made, but in performing this operation the danger of severe hæmorrhage must not be forgotten. The treatment of these cases is, however, beyond the province of a dentist.

Chronic abscess of the tongue may follow deep-seated inflammation. It simulates in appearance a cyst. It is circumscribed, and lies immediately below the mucous membrane, which may be moveable over it. It is smooth on the surface, and not generally tender; and fluctuation may be perceptible. Its position is most commonly the dorsum of the tongue in front of the circumvallate papillæ. Mucous cysts are found generally further back. It is more frequent in adults than children.

The treatment is the same as that of abscess elsewhere; but in making incisions into the tongue its great vascularity must be borne in mind.

ABRASION. EROSION. INJURIES— CONCUSSION, DISLOCATION, AND FRACTURE OF TEETH.

Abrasion.—As age advances the teeth become ground down by mastication. The enamel is first worn off, next the dentine suffers, and in time the pulp would be laid bare were it not that it almost invariably undergoes calcification on the surface *pari passu* with the slow destruction of the hard tissues. The amount of abrasion in every case depends, of course, on the density of the teeth, and on the kind of usage to which they are subjected, and to some extent on the bite—the manner in which the teeth articulate. If the bite be normal, abrasion of the front teeth rarely becomes excessive, but if these teeth meet edge to edge they may become worn down, sometimes even to the level of the gum. In rare cases, from some unexplained cause, the front teeth are ground down more rapidly than the molars, so that after a time, on closure of the mouth, the incisors of the opposing jaws cannot be brought into contact. Abrasion of the teeth of this slow kind is, in most instances, unattended with suffering, but it is occasionally accompanied by tenderness or pain due to exposure of sensitive dentine, or to approaching exposure of the pulp.

Treatment.—When the tenderness is slight it may usually be cured by application of zinc chloride or silver

nitrate in the manner several times already described. In some cases the dentine being worn down more than the surrounding enamel a shallow cavity is formed. This, in some instances, can be filled with gold or amalgam after having been slightly deepened and retaining grooves cut around. In some few cases the crowns may be cut away sufficiently, without approaching the pulp, to allow a gold cap to be fixed.

In some few cases the tenderness of the surface resists treatment, the sensibility recurring in a few hours after each application of a caustic. In others, still less amenable, the surface becomes exquisitely sensitive, so that a pang of pain is excited even by merely drawing lightly a sharp-pointed probe over it; and the use of the tooth in mastication becomes impossible. With this condition neuralgic pain is often associated. These cases are to be accounted for on the supposition that minute nerve fibrils of the pulp lie close to or at the surface of the secondary dentine. In some of these instances the only treatment, short of extraction, consists in drilling into the pulp-chamber, extirpating the pulp, and filling the roots and cavity, or putting on a gold cap. The pain of the drilling being unbearable, nitrous oxide must be given. The operator standing ready with sharp spear-pointed drill cuts as rapidly as possible towards the pulp-chamber during the anæsthesia. If the pulp-chamber be not reached, a hole large enough to contain a dose of arsenic may be formed, and the sensibility may be diminished sufficiently to allow of further drilling without an anæsthetic; and further treatment with arsenic may be continued until the pulp is completely destroyed.

Erosion.—Erosion is a term used to designate a peculiar form of slow wasting of certain surfaces of the teeth, occurring mostly along the labial face of the

necks, where it forms grooves of characteristic form. Erosion is seldom, if ever, met with before middle age. It often occurs in mouths singularly free from caries, and in robust patients of a gouty temperament. Erosion is distinct from, although sometimes mistaken for caries, and perhaps a summary of the points in which it differs from caries would contain almost all the knowledge we possess upon the matter. Like caries it is a destructive process proceeding from without inwards, but there the resemblance ceases. In erosion the tissue that suffers most is enamel ; in caries, dentine. Erosion scarcely ever forms an undercut cavity ; caries almost always does so. An eroded surface is always hard and polished; a carious surface always more or less soft and rough. Erosion shows no preference for fissures or sheltered crevices, but destroys those surfaces most constantly rubbed by the lips and tongue and washed by saliva. It sometimes presents the appearance caused by friction of a band, but since it is often found in mouths where no artificial teeth have been worn, this hypothesis does not always explain its presence. Erosion cannot be due, in all cases, to the use of tooth-brushes or tooth-powders, for it is common amongst those who never clean their teeth.

The etiology of erosion, like many other similar dental subjects, has formed the theme of voluminous writings and much speculation. The limitations of theory are, however, here as elsewhere, sharply marked by physiological facts. Enamel containing no active physiological elements is incapable of pathological change or of any process resembling ulceration. If the surface of enamel waste, the waste can be due only to external agents and agencies. Acid capable of dissolving the tissue may be secreted by the mucous membrane; and minute particles of food lodging around the necks

of the teeth, .and fermenting may increase the supply. The process of erosion is, with very rare exceptions, an exceedingly slow one, years being usually taken to produce a shallow excavation. After each solution of the surface, to a microscopical extent, the movements of the tongue and lips, the flow of saliva, and sometimes friction during mastication, polish the slightly affected surface ; and so the process of alternate denudation and polishing goes on. This process corresponds somewhat to the wearing down of masticating surfaces of honeycombed teeth affected by caries, described in an earlier page under the heading—spontaneous arrest of caries. A polished surface is produced in these cases by friction, whilst the caries of surfaces of the same teeth not subject to friction continues unchecked. When erosion cavities become deepened so that they retain particles of food for prolonged periods and are not swept out easily by the agencies mentioned above, the surface softens and the disease takes on the form of ordinary caries—a fact of sufficient significance.

In some cases it is possible to observe that after the patient has taken food a narrow line of minute particles always tends to lodge in some situations around the necks of certain teeth where a hollow, bounded by the free edge of the gum, exists. Fermentation of these particles would, within a few hours, produce enough acid to dissolve a microscopical film of enamel.

It is certain that erosion can be due alone to chemical and mechanical causes acting externally to the teeth ; but it is rarely possible to ascertain why it attacks certain teeth by preference in each case, and why certain surfaces only of those teeth. Mr. A. Underwood has shown that enamel of some teeth, the seat of erosion, is structurally defective, granular in character, and more easily acted upon by acid than well made tissue. Dr. Black has further

shown that enamel exposed to a continuous current of slightly acid fluid undergoes wasting very closely resembling erosion. The existence of acid secretions, which may be kept constantly in motion over the teeth by the movement of the tongue, cheeks, and lips, seems enough to account for erosion. Its varying incidence would be accounted for by structural weakness in enamel occurring in different situations, and by the configuration of the teeth, which exhibits infinite variation in different individuals, and which exposes some surfaces more than others at once to the action of acid and to friction from the tongue and lips.

The treatment of erosion may, in some cases, call for attention to the general health, particularly in gouty subjects and in those whose buccal secretions show acidity. An alkaline tooth powder should be used with a soft tooth-brush, and an antiseptic lotion may be prescribed. But it must be confessed that measures like these can seldom be recognised to have any influence over the slow progress of the affection. If exposed dentine display sensibility and cause pain it may be treated by application of chloride of zinc, a minute fragment of the salt being rubbed on to the moist surface occasionally. As soon as the eroded surfaces become deepened and extend into the dentine the best treatment consists in filling the cavities or inlaying them with porcelain. Inlays entirely prevent disfigurement, which, as the front teeth are mostly affected, is an important consideration. Very perfect and permanent work can, in these cases, be done with moulded inlays. Filling or inlaying, in the majority of cases, puts an end to the progress of erosition.

Fracture of the Teeth may arise from injury, such as a blow upon the mouth, or may occur during mastication, as when a fragment of bone, a small gritty particle, or a

shot in game is bitten upon. Most practitioners meet with cases, and many are recorded, in which the crown of a tooth has been cleft in twain by accident during mastication. The teeth have been bicuspids or molars, some hard foreign body having lodged between the cusps during forcible closure of the jaws. In many of these cases the patients having experienced little pain at the time seemed unaware of the accident; or having forgotten it and applying later complaining of uneasiness in the tooth, the character of the trouble was revealed by careful examination.

If the fracture, however caused, do not lay open the pulp cavity it will often suffice to file down the rough surface and carefully polish it. In other cases, if the fractured surface is of such a shape as to form a cavity, or so situated that filling appears desirable, a stopping may be inserted. If the pulp be exposed by the injury, and the fracture extend in a vertical direction and to more than a slight extent into the root, the extraction of the tooth may be called for, but if the fracture involve only the crown, an attempt may be made to save the tooth, or at least the root. The pulp in most cases must be at once destroyed, after which fang-filling may be performed, or an artificial crown may be attached to the root in the manner elsewhere described. If the root be transversely fractured deeply within the socket, extraction will usually be called for. Some few cases are, however, recorded in which a root completely fractured transversely has united and the tooth has remained useful for years. The union in these cases was effected by deposition of cement and in some instances calcification of the exposed pulp at the seat of fracture. The question of supporting and protecting a fractured front tooth in the hope of repair taking place is therefore, perhaps, in some very few cases worth consideration.

In a very large proportion of cases of fracture of a crown of a front tooth with opening of the pulp-chamber in children and youthful patients the best practice is extraction of the tooth; and this may always be carried out without hesitation when the jaw is very crowded. In all such cases the space is certain to close in time by the spreading apart of the crowded set; and although some slight disfigurement or want of symmetry may be perceptible this will be reckoned a smaller disadvantage than the necessity of wearing, sooner or later, an artificial tooth on a plate. When the jaw is not very crowded, and the space not likely to close completely without treatment, a regulating-plate may be made to hasten the progress. A case of this kind was described in the chapter on "Irregularities" and illustrated in figs. 92 and 93. The danger of setting up periodontitis during extirpation of the pulp and the fixing of a pivot is great in proportion to the youth of the patient; and even if successfully fixed it is probable that ten years would constitute the longest average period the tooth would endure. A new tooth on a plate would then be needed to be worn for life. A plate attached to neighbouring teeth will in time, in spite of care, injure them; whilst a large "suction" plate for a single tooth must form a constant source of discomfort. The most difficult cases of this kind in which to judge the best course to be pursued are those in young girls in whom appearance is considered most important. In these cases the advantages of the different courses must be explained; and as the matter is one in which the guardians may safely be allowed to decide, their wishes may in most cases be respected.

The unsymmetrical appearance caused by closing up of the set after the loss of a front tooth may be often mitigated by filing off of some angles or reducing

edges of adjacent teeth when the patient has reached adult age.

Concussion.—A blow upon a tooth which may be followed by only slight immediate suffering will occasionally give rise to severe symptoms after lapse of months or years, when very often the injury has been forgotten by the patient. Injuries of this kind are very apt to occur to boys engaged in school games. A front tooth receives a hard knock, remains tender, perhaps somewhat loose, for some days, and then slowly recovers and becomes firm again. After a time attention is again attracted to the tooth; it becomes either the centre of an attack of acute inflammation—alveolar abscess—or the seat of chronic periostitis. On examination the tooth is found free from caries and the pulp dead. This latter fact is evident from the characteristic darkened hue of the tooth, and it can be proved by the heat test. A heated steel instrument applied to the crown over the situation of the pulp-chamber does not give rise to sensation such as neighbouring teeth with living pulps display. The patient being questioned will usually recall the circumstances of an old injury. Care must be taken not to confound this condition with pyorrhœa alveolaris — a mistake which a novice might well make. Pyorrhœa never occurs in youthful subjects. In pyorrhœa the pulp in the vast majority of cases is alive, and the characteristic appearances of the gum with muco-purulent discharge from within its free edge cannot be mistaken by an experienced observer. Abscess following concussion, although often very acute, is sometimes extremely chronic, a large collection of pus slowly accumulating, beneath the gum over the tooth, without much pain or other urgent symptoms. The abscess usually bursts through the gum over the apex of the root; but in some cases matter wells up around

the tooth from the alveolus. Sometimes the pus burrows to a distance.

Treatment.—Concussion at the time of injury calls for the same treatment as periostitis—rest, bleeding, and hot fomentations. If the pulp be dead the case must be dealt with exactly in the manner prescribed for cases of death of the pulp following filling in caries. The pulp-chamber can be opened by a drill. In upper and lower incisors and canines this opening should be made through the posterior surface of the crown in an oblique direction favourable for the admission of nerve instruments. The pulp-chamber, which may contain the gangrenous pulp entire, but which will more often be found to contain fœtid pus only, must be cleared and the canal dealt with in the manner described in a previous chapter. At the same time the abscess, if there be one, must be opened and evacuated and treated as an ordinary alveolar abscess.

Dislocation of the Teeth, and more particularly front teeth, is not an uncommon effect of blows upon the mouth. It may occur as an accident during extraction, as mentioned in a later page. Sometimes the tooth is only started from the socket or partly dislocated; sometimes it is completely dislodged.

Treatment.—If partly dislocated the tooth must be pushed back into the socket. In complete dislocation, if the case be seen within a few hours, the tooth may be replanted in the socket. The socket should be first washed out with syringe and warm water, to clear it of coagulated blood, and the tooth having been also cleansed and washed in an antiseptic lotion, such as perchloride of mercury 1 in 5,000, or carbolic acid 1 in 50, should be replaced in the socket. If but a short time has elapsed after the tooth was knocked out, if great care be taken to support the tooth by ligatures and

to guard it from injury, it will in favourable cases regain its attachment to the socket, and may remain firm for years. In cases where the tooth has been separated for hours success is more likely to attend replantation, if the pulp be extracted through the apical foramen and the canal filled with antiseptic stopping. It is probable that in every case of complete dislocation, except perhaps in rare instances in which the tooth is at once returned to its socket, death of the pulp ensues; and it becomes a question whether it may not as a rule be the better practice, before replanting the tooth, to extirpate the pulp and fill the canal, *via* the apical foramen in every such instance. After this treatment, as also after replacement of a partly dislocated tooth, there may supervene an attack of acute periodontitis, which must be treated in the manner described on another page. In cases of partial dislocation death of the pulp may possibly occur either at once or apparently after an interval; and the case then calls for the treatment prescribed for the same condition following concussion.

Cases in which teeth are driven by violence into their alveoli partake partly of the nature of dislocation, partly of fracture of bone; for it seems hardly possible for a tooth to be so dislocated without some splitting asunder of the alveolus. This accident seldom occurs except to the upper centrals and canines, and is caused either by an upward blow or by a fall forward on the face. The treatment consists in drawing the teeth down to their proper level and supporting them by wires, ligatures or splints, and pressing the bone when necessary into position. Inflammatory symptoms must be dealt with as they arise. The prognosis in adults is extremely unfavourable. Considerable inflammation usually supervenes, and the teeth become necrosed. Sometimes portions of fractured bone also exfoliate. In

children recovery is more probable. This fact was exemplified in a case recently under treatment. A girl aged eight was thrown from a carriage on to the road upon her face. She was seen five hours after the accident. Beside other injuries it was found that one upper central incisor was missing, the alveolus being empty; whilst the other central and the laterals had been driven so far into their sockets that five-sixths of the crowns had disappeared, and their cutting edges were barely visible through the swollen gum. The teeth were separately grasped with forceps and slowly drawn down to their proper position in relation to the bone of the alveolar border which served as a guide. They were then so loose as to be with difficulty prevented from falling out. The alveolar walls were compressed where they seemed forced apart. The teeth were ligatured, but not very effectually, owing to absence of permanent teeth except the first molars, and a vulcanite frame was made to support them. The child was kept for a time upon liquid diet. In this case perfect recovery took place. The teeth a year after the accident were firm in position, with living pulps and the bone had consolidated. The space previously occupied by the missing central had considerably diminished.

PIVOT TEETH. ARTIFICIAL CROWNS. BAR AND BRIDGE WORK.*

After the partial or complete destruction of the crown of a tooth by injury or disease, it is possible in many cases to attach permanently an artificial crown to the root by means of pegs or pivots fixed in the pulp canals —the pulp having been, of course, previously extirpated. The incisors and canines were once considered alone suitable for this operation, but the advance of antiseptic methods, whereby the conservative treatment of decayed roots has been made more easy and certain, has rendered possible successful practice of similar operations (modified to meet the different conditions) on any tooth. The roots should be free from disease. If periodontitis exist, it must be treated, and even in cases where no symptoms are apparent it is good practice to dress the canals, and to plug them for a few days before

* In deference to the opinions of leading medical reviewers, a fuller sketch of these subjects has been written for this than was given in the earlier edition. The main purpose is to explain the general scope of this branch of prosthetic dentistry for the benefit of the medical reader. Mechanical or prosthetic dentistry is practised by the vast majority of dental surgeons. Problems of surgery are included in almost every case where artificial teeth are called for; and these cases cannot properly be handed over to a mere mechanic, however skilful and intelligent. Such a one, however honest and well-intentioned, must, constantly (through lack of necessary knowledge), inflict upon the patient pain and injury which might easily be avoided. Prosthetic dentistry is, however, a very large subject. The dental student gains his instruction in the laboratory, where he is obliged to undergo training at the work-bench during three years; he attends the lectures on the subject which are included in the curriculum, and gains further theoretical knowledge from general handbooks and from monographs on special subjects. An attempt at more than an outline of these subjects would obviously be out of place in a manual of Dental Surgery.

permanently closing them. An attack of acute periodontitis will often follow the operation if this precaution be not observed.

Pivot Teeth.—In preparing an incisor or canine for the simplest form of pivot the remaining portion of the crown must be excised. This is accomplished by means of a small saw, cutting forceps and suitable files. The edge of the root must be reduced to the level of, or to a line or two within the free edge of, the gum, and its surface should be concave. The canal must be reduced to an equal calibre throughout, to near the apex. In these operations the dental engine will of course be used. The most suitable calibre for the canal is one that will admit a wire of ordinary "dental pin" size. It often happens, however, that the canal has been already enlarged to a greater size by decay, and in such cases the softened tissue must be cut away, and the walls of the cavity rendered smooth. The canal in some of these cases must remain tapering in form.

A model of the part should then be taken by the following method. A metal pin is cut to fit the canal accurately, and long enough to project slightly beyond the orifice when inserted. With this pin in place an impression of the root and adjacent teeth is taken in the usual way, and in this the pin comes away. The model, which needs to include merely the approximal outlines of the two adjacent teeth, should be taken in plaster of Paris—the only material from which a perfect and clean-cut cast can be made. The cast which is prepared from the impression shows, on withdrawal of the pin, the size and diameter of the canal. An artificial crown can be fitted to the root and attached to a pivot in the patient's absence.

Artificial crowns are made of porcelain of all sizes and shades to match the natural teeth. Platinum pins

or tubes are fused into them in the making, so that they may be soldered or fixed to the pivot. By means of corundum wheels on a lathe these teeth are ground and fitted accurately to the surface of the roots.

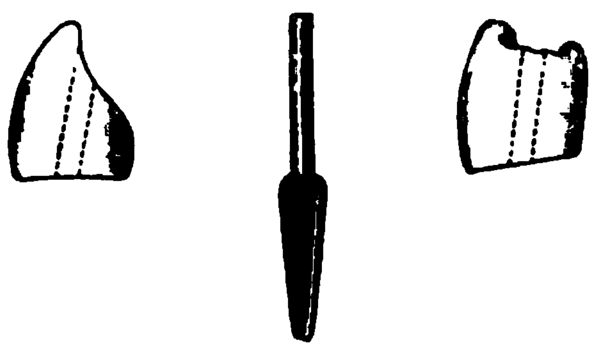
Pivots are made of gold or platinum. The pivots should fit the canal accurately but not tightly, and should be roughened or barbed. A succession of minute barbs can be made by drawing a sharp steel blade around the pin at close intervals. The pin is next bound with one thin layer of fine floss silk specially made for this purpose. The canal must next be dried antiseptically and the pivot tried lest the silk and barbs may have made it too tight. If too tight or the alignment of the pivot be altered by an uneven layer of silk, the crown may be more or less tilted, and the base will not fit closely to the root. Cement is then mixed very thin, and some passed into the canal and the pivot thoroughly coated and soaked with the same. The pivot is then inserted. Some difficulty will be found in forcing it home until by working it to and fro a portion of the cement is allowed to escape. A moderate amount of force at the last may be exercised, through steady pressure, to drive in the pivot. Exclusion of moisture until the cement has hardened is desirable. This plan makes a very secure joint, and at the same time ensures complete plugging of the canal to the apex. If the apical foramen appears unusually open, it must be closed by a short plug before insertion of the pivot.

Root canals much enlarged by decay may often be made to securely hold a pivot by plugging. Gold or amalgam — copper amalgam answers well — may be employed. An iron pin may be inserted and the filling packed around. When the filling has hardened the pin can be withdrawn and a porcelain tooth prepared, the pivot, where amalgam is used, being of

platinum. Some operators prefer a pin of soft wood —such as orange—which, after hardening of the amalgam, is easily removed by a drill. A more beautiful operation consists in inserting a gold tube and packing gold around.

Fig. 212 illustrates a simple pivot designed by Mr. Nash, of Inverness. The crowns are, as usual, of porcelain, with a platinum tube running through. The crown having been fitted to the root, the lower orifice of the tube is countersunk to take the shoulder of the pin. The pivot, with a special instrument for the purpose, is then bent so that the crown may assume the proper position with its base closely fitting to the surface of the root. The pivot is then soldered into the porcelain

FIG. 212.



tooth, and the projecting end having been reduced to fit the canal, the pivot is ready for fixing. The fixing is carried out by the method already described; but some operators prefer to use cement without any binding of the pin with floss silk. This method is applicable to bicuspids and molars, but most operators will prefer for these teeth a "collar" or a "cap" crown, which protect the exposed surface of the root and distribute the strain more equally than can be ensured by pivots alone.

A simple method of pivoting front teeth has been lately introduced by Dr. Leon Williams. This is illustrated in fig. 213. Pivots are provided to which a platinum foil

diaphragm with a ring on its internal aspect are affixed. A groove of the exact size is cut in the root with a special instrument to receive the ring. The platinum is then burnished to the root, and the artificial crown having been fitted, is mounted in the usual manner.

With a view to distributing strain, protecting the surface of the root, and adding strength to the whole,

FIG. 213.

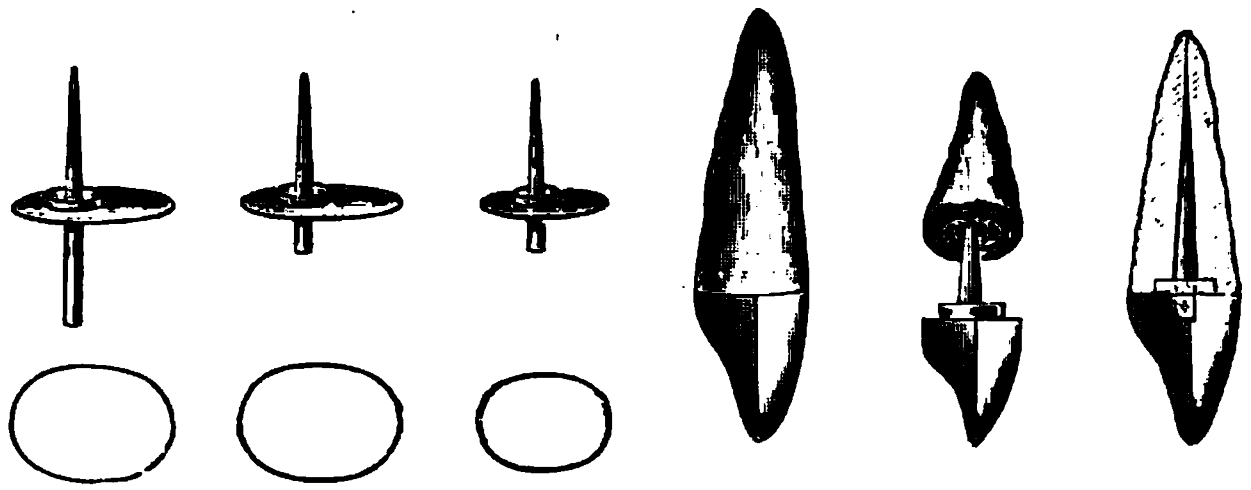
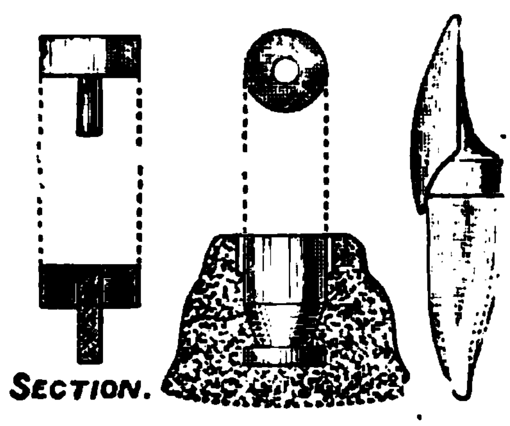


FIG. 214



several ingenious modifications of the simpler processes of pivoting have been introduced in late years.

The root to be so treated is ground down slightly below the level of the gum and is given a slightly conical shape by means of burrs worked in the dental engine. A collar of thin gold is fitted and burnished to the root at the edges where it passes below the gum level. It is next soldered to form a ring and

formed into a cap by soldering a flat piece of gold over it. The position of the root canal having been marked, a hole is drilled through the cap and a gold pin fitted through it into the canal, and again the parts are soldered together. A tube tooth may be fitted to the projecting pin or a flat tooth may be used, and, if necessary, the contour posteriorily can be restored with gold solder.

The Büttner method is illustrated in fig. 214. With this method the root is ground down slightly below the gum level and cut perfectly circular by a special trephine. Gold caps are supplied of sizes corresponding to the trephines, and one is chosen to fit the root. The further stages of the operation do not differ from that above described. This method has the disadvantage of being only applicable to roots which in shape naturally tend towards the circular, and in practice it will be found that the upper central and lateral incisors are the ones most adapted to its use.

Incisor and canine pivot teeth should be arranged to escape contact with the teeth of the opposing jaw, so far as possible during mastication. Where the bite is close, a flat tooth is most suitable; where the bite is free, a tube tooth may be employed.

The teeth in fig. 212 are "tube" teeth. A "flat" tooth consists of face of porcelain in the posterior surface of which two small platinum pins are fixed. A backing of gold plate is rivetted to these pins after the porcelain has been fitted to the root, and the whole, in finishing, is soldered with gold to a gold or platinum base covering the tooth. With these teeth the impact of antagonising teeth and the strain of mastication are borne mainly by the gold back; and the porcelain is thus protected from fracture. A flat tooth is shown in fig. 214.

Artificial Crowns.—The operation of crowning bicuspids and molars gives scope for a great deal of ingenuity, and the practitioner has the choice of a considerable variety of artificial crowns in porcelain and metal now supplied by manufacturers to meet the exigencies of cases. If the labial wall of the crown of a bicuspid is sufficiently strong, it may be often preserved by a stopping having its foundation in the root, and being strengthened by pivots secured in the canals. Otherwise, for the sake of appearance, the patient will prefer a porcelain crown ; or, if the lingual wall of

FIG. 215.

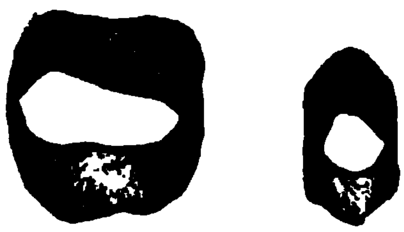
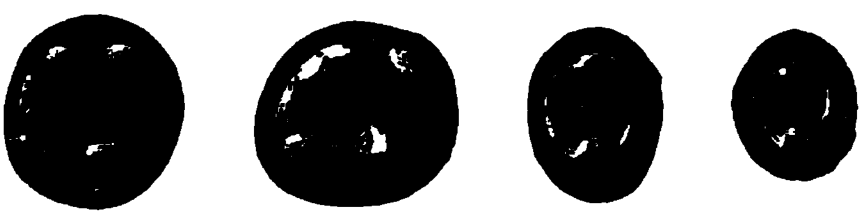


FIG. 216.



the tooth still stands, a flat porcelain front on a pivot may be secured with filling to restore the crown. The molars are to be dealt with on similar lines. Pivots may be secured in all or either of the roots, and fillings may be built up around these. A beautiful operation consists in preparing a hollow gold crown to fit over a truncated tooth, fixing it in position with a mass of cement anchored and secured to a mass of stopping springing from the roots, in the canals of which pivots have been previously fastened.

Two varieties of these hollow gold crowns are in general use: one made in two separate pieces subsequently soldered together, and one made seamless. The former is the one most generally used in practice. The tooth to be crowned is prepared in the manner previously described and ground as nearly circular as possible. If its walls are sufficiently strong they may be left standing as high as convenient, if weak they may be strengthened with amalgam. In any case where the tooth is decayed below the margin of the gum it may be carefully restored before crowning with a metal stopping. To make a gold crown a strip of gold plate is carefully fitted to the root and soldered to form a ring as seen in fig. 215. It is next placed upon the root, filled with modelling composition, and the patient directed to bite upon it. By this means a model of the occlusion of the opposing tooth or teeth is taken. A cap, fig. 216, representing as nearly as possible the original cusps of the tooth, is next "struck up" (embossed), between metal dies, soldered to the band, carefully finished and polished. The crown is now ready to be fixed. If it is deemed advisable, a metal pin to pass into the root canal may be soldered into it. It is most important in making gold crowns that they should be of such shape as will avoid the retention of food between them and the neighbouring teeth. For this reason they should always tend to a circular rather than a rectangular shape. Gold caps to suit all cases are now supplied by manufacturers.

If it be deemed advisable, porcelain faces may be adjusted and fixed into any of these crowns, or specially prepared porcelain cusps may be fixed to the gold collar in lieu of gold, thus preventing disfigurement.

By one or other of the preceding methods, teeth, even when extensively decayed, provided their roots be healthy or capable of being brought into a healthy

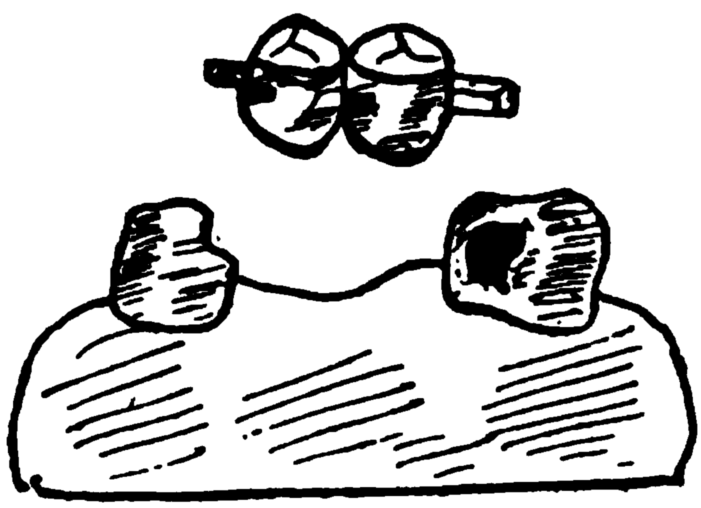
condition, may be preserved and made serviceable for years.

Bar and Bridge Work.—Where a number of truncated teeth and roots exist in a mouth with intervals whence teeth have been lost, it is sometimes possible to fix upon them a row of artificial crowns permanently and securely. The teeth are mounted on a gold bridge or bar provided with pivots and projections, which are secured by stopping into the roots and cavities. Metal collars may be also carried round broken-down crowns. The choice of cases for this treatment calls for nice discrimination. Like all advances in the dental art it has become a field for quackery.* Patients are always anxious to avoid the employment of the usual plate for artificial teeth, which of course, is dispensed with in bar work. But in many cases decayed teeth and roots, although they will carry safely a moderate-sized stopping, will not bear the greater strain which this kind of work puts upon them. Chronic periodontitis may be excited, or acute inflammation, which would necessitate removal of the work. Owing to the tension caused by the rigid metal frame with its firmly anchored attachments, acute inflammation around roots beneath a piece of bar work often runs a very virulent course, and it is exceedingly bad practice to fix work of this kind over roots the seat of pathological conditions likely to assume an active

* The extent to which dental quackery—at once fraudulent and cruel—is still pursued is probably realised only by practitioners of long experience. The quack dentist—who now frequently carries on his trade under the cloak of a sham American "Institution"—obtains immunity mainly owing to the fact that patients, as a rule, will silently endure almost any injury or pecuniary loss, rather than make a public exposure of their folly or weakness. Cases in the courts of law, throwing sufficient light upon dubious methods, are, however, occasionally reported in the public press. If such cases do not more often obtain publicity this is to be ascribed to the fact that a quack, when pressed, will almost invariably refund his fee (very often three or four times the amount a reputable practitioner would have asked for honest work), and pay reasonable damages rather than face the ordeal of an action for malpractice.

character. In some cases a very close bite leads to frequent fracture of the artificial crowns, which are then with difficulty repaired. In other instances, the lodgment of decomposing particles beneath rendering the part foul and unhealthy, it is impossible to construct an apparatus which can be kept clean without removal.

FIG. 217



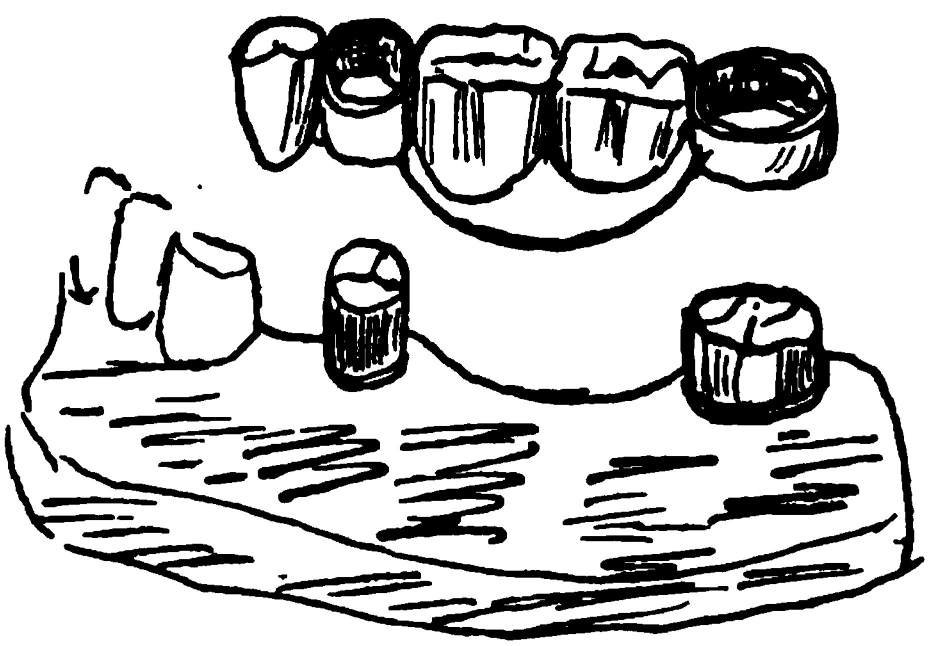
Description of a few cases may suffice to make this subject sufficiently understood. Fig. 217 shows a simple case where two teeth only are missing, and are to be replaced by artificial substitutes, soldered to a bar, and fixed by gold or amalgam fillings into cavities in adjacent pulpless teeth. A better method, especially if either or both the teeth used as butresses are broken down, is to fit them with gold caps and solder to them the artificial crowns. The teeth used to fill the gaps are styled "dummies." They are roughly triangular in section, the apex of the triangle resting on the gum in such manner as to afford little or no lodgment for *débris* of food. A further modification may be made by doing away with the intervening teeth and filling the gaps by means of a solid gold bar, fig. 218. In cases where appearance has not to be considered, as for example far back in the mouth, such work combines the maximum

of utility, strength and cleanliness, lodgment of food being practically impossible as the free space between the masticating bar and the gum is easily cleared by the tongue.

FIG. 218.

Bridge work may be made removable. Fig. 219 represents such a case. The molar and bicuspid are crowned with gold caps, and gold bands are accurately fitted over them. A gold saddle bearing two tube teeth is fitted to the interval between the natural crowns; the

FIG. 219.



space between the canine and the cap on the bicuspids is occupied by a "dummy." Rings, saddle, and dummy are soldered together, and the completed bridge may be slipped over the crowned teeth at will. To fix

such a case immovably, the bridge would, in the making, be soldered to the cap crowns. It is not advisable to construct very extensive bridges. It is better, as a rule, to insert several small bridges than one large one where practicable—for it must be borne in mind that if one only of the roots supporting the bridge becomes diseased, the whole bridge has possibly to be removed. When finally fixed in position it is frequently a difficult matter to remove a bridge, and it may be found necessary sometimes almost to destroy it in the process. As little porcelain as possible should be used. All masticating surfaces should be made of gold, and corners or pits allowing accumulation of food particles carefully avoided. Strength and facility of cleaning are essential in bridge work.

SALIVARY CALCULUS OR TARTAR.

SALIVA, among its other constituents, holds in solution a small proportion of earthy salts, and these salts are very liable to be deposited upon the teeth in the form of a concretion—salivary calculus or tartar. There are indeed few mouths, however healthy, which are absolutely free from deposit of tartar, whilst in some individuals with disordered health, and with local conditions favourable to the formation, it accumulates in enormous quantities. In health the saliva secreted by the parotid, sublingual, and submaxillary glands is alkaline, while that secreted by the buccal glands is slightly acid.

Diseases associated with disorders of the digestive organs and with vitiation of the secretions of the mouth predispose to the formation of tartar. It is deposited upon teeth which are not subject to the friction of mastication, and it is common to see the teeth of one side of the jaw covered by the concretion when the presence of tender teeth compels the patient to use the other side alone. It accumulates often in great masses around teeth the alveoli of which are undergoing absorption. Accumulation of tartar is in most cases greatest upon the external labial surfaces of the upper molars and on the lingual aspects of the lower front teeth, owing to the proximity of these surfaces to the orifices of the salivary ducts.

The density and colour of tartar vary considerably. When rapidly deposited it is soft and friable, and light yellow in colour; when slowly formed it is hard and darker in colour—brown, greenish, or even quite black. Where great masses exist they are often composed of strata of varying colour and density.

Analysis of tartar shows its composition to be as follows:—

Earthy phosphates . . .	79·0
Salivary mucus . . .	12·5
Ptyalin	1·0
Animal matter	7·5

This analysis is only approximate, the composition of tartar being very inconstant. When recently deposited the animal matter which chiefly consists of micro-organisms is greatly in excess. If allowed to remain, this animal matter dries up and the mass comes to consist mainly of lime salts.

According to Tomes, salivary calculus differs somewhat in chemical composition according to the situation in the mouth where it is deposited. Thus that formed near Steno's duct contains most carbonate of lime, whilst in that deposited on the lower incisors phosphate of lime preponderates.

Microscopical examination shows that the animal matter entering into the formation of tartar is made up of micro-organisms of every variety from huge bacilli to micrococci, and the *débris* of broken-down epithelial cells, whilst numerous filaments of leptothrix are always present in the mass.

The peculiar green discolouration occurring upon the teeth of children, and most frequently affecting the labial surfaces of the front teeth, appears to be due to staining of Nasmyth's membrane, or possibly to a deposit of leptothrix. The discoloration produced by

the bacteria most commonly present in the mouth is brown or yellow.

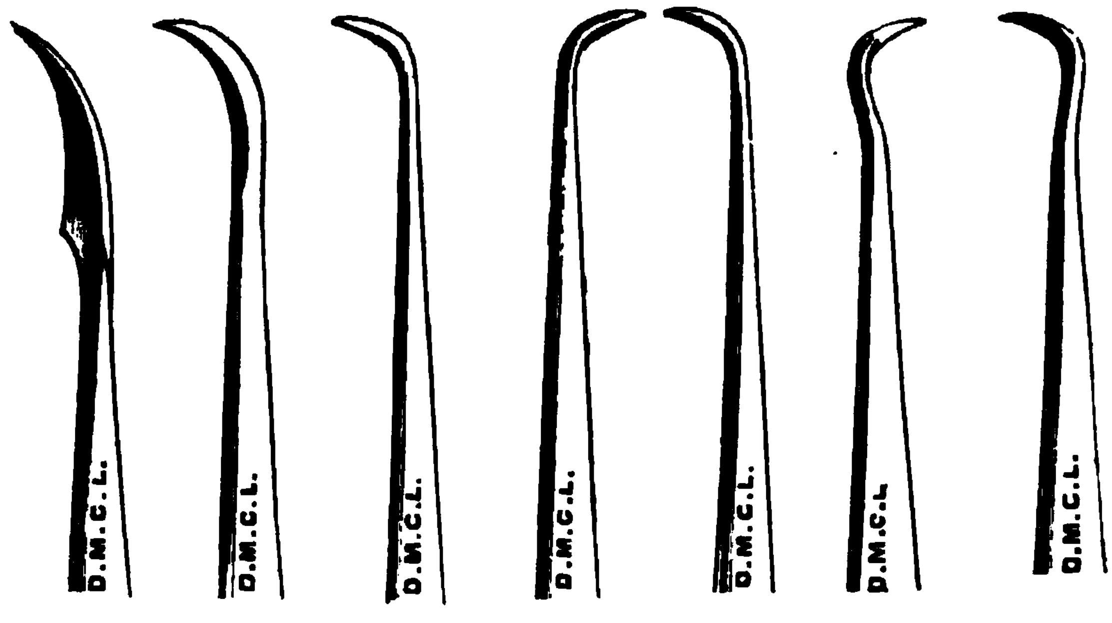
Deposition of tartar occasionally begins around the necks of the teeth beneath the free edge of the gum, and, acting as a foreign body, it keeps up chronic inflammation of the gums and dental periosteum, and thus may constitute, in some instances, the sole cause of absorption of both gums and alveoli.

In many cases where no other disease is present, it is, however, impossible to say whether the tartar has caused the recession of the gums or has been deposited as the gums have receded. In some instances the tartar is found attached around the necks of teeth and overlaying the gums which are not notably wasted. The tartar, on removal, discloses the gum on which it has rested, and this is usually found stript of epithelium, red, and bleeding. Where pyorrhœa alveolaris, or other similar disease causing wasting of the alveoli is present, tartar always accumulates to a greater or less extent, and to it is often ascribed a share in causing or hastening the loss of the teeth. The peculiar round hard nodules found around the roots within the "pockets" of the gum in pyorrhœa have been mentioned in the description of that disease.

Treatment.—Careful use of the toothbrush and due exercise of the teeth in mastication will do much to retard and prevent the deposition of tartar, but where these fail the deposit, if of great extent, must be removed by suitable scaling instruments. Although tartar adheres tenaciously it does not, of course, penetrate; and unless as in honeycombed teeth the surface of enamel be rough it is possible in most cases by careful manipulation to detach the concretion completely in scaly masses from each tooth. To remove masses by scraping would be a long, fatiguing and unsatisfactory process. The

aim should be to cut through the layer upon each tooth to the surface of the enamel or root, and then by a levering movement to split it cleanly away in flakes. Scalers of various patterns light and well designed, a great advance on old-fashioned clumsy shapes, are now made. Some of these have chisel blades; others are thin and flexible, and some of each kind are curved to reach different surfaces. Some are provided with curved blades adapted to the contour of roots, and to be used with a drawing movement. These are especially useful

FIG. 220.



in detaching the nodules in pyorrhœa. A useful set of scalers is shown in fig. 220. Chisel blades are not included in this set, nor is one with a flat narrow thin curved blade fitted to pass round the necks of some teeth. Sometimes, as in lower front teeth when not very crowded, the passage from the front of a thin curved scaler through the spaces with the point of the instrument directed upon the surface of the enamel near the neck, will effect the dislodgment in one movement of the whole mass around the tooth.

Owing to congestion and swelling of the free edges of the gums, which almost invariably accompany the presence of tartar, oozing of blood mostly goes on during scaling, and tends, in spite of free syringing, to hide the parts from view. Removal of the great bulk of the deposit having been effected, it is often well to wait a few days before proceeding with the operation. In the interval the gums will have often become more healthy, and the remains of tartar may then be more certainly found and removed. Several sittings will be needed in many cases.

In neglected cases, where a large accumulation of tartar is found investing and binding together the teeth in one solid mass, caution must be exercised in proposing its removal. In such cases where great absorption of the alveoli has taken place the teeth will be found so loose as hardly to stand the force necessary in dislodging the tartar, or by loss of the covering and support which the tartar had afforded, may be rendered so tender or so weakened as to call for extraction—an operation to which the patient may very strongly object. This condition very often is found in connection with lower front teeth in elderly people. Sometimes in such instances if the tartar be removed the teeth are rendered unbearably sensitive to changes of temperature; so that, in spite of the need on many grounds for its removal, the tarter, in such cases, has to be left until the teeth are shed, or extracted when very loose.

Superficial discolouration—such as occurs in children—is best removed by pummice powder, with water, and a wooden or cane point, or much more effectively and rapidly with the polishing discs and cones which are now used with the dental engine.

In the operation of scaling it is of importance not only that every particle of tartar be removed, but also that

the surface of the tooth be left perfectly smooth, since a rough surface favours rapid re-deposition. The teeth, when necessary, can be polished after the operation by the method just mentioned. Such polishing can be rarely necessary save on root surfaces. Tartar can always be completely detached in masses from enamel, and in most cases from the surface of roots as well.

MORBID GROWTHS CONNECTED WITH THE TEETH.

Odontomes.—Under this name have been classified and described several varieties of malformed and monstrous teeth and neoplasms composed of confused masses of dental tissues. These growths are very rare, and may well be styled pathological curiosities; but being direct derivations from the teeth and their environment, they must be particularly interesting to the dental surgeon. Their etiology has been clearly made out only within late years. Much light was thrown upon the subject by the researches in earlier times of Forget, Broca, and Magitôt. In later years more knowledge was gained by the labours of Sir J. Tomes, C. Tomes, C. Heath, Salter, and McEve. Mr. Bland Sutton* collated all these authorities and went over the subject himself, approaching it mainly from the point of view of evolution and embryology—a method through which he had previously elucidated many pathological problems of a similar kind. In the following description of these dental tumours an endeavour has been made to embody an epitome of Mr. Sutton's work, which there can be no doubt is substantially accurate and complete.

It appears certain that odontomes can originate only during development of the teeth. At this period (as we have seen) the teeth are represented by soft tissues,

* Dermoids, 1890. Numerous Papers on Dental Pathology, Transactions Odontological Society, &c., 1883 to 1890.

which gradually assume the form of the future organs, and become calcified. During this stage of growth the formative elements may become the seat of partial or general hypertrophy or other morbid action followed by more or less complete calcification. The morbid process may be confined to the enamel organ, or to the dentine pulp, or may involve the follicle and all the tissues of the tooth. The most simple form of these growths is displayed in what have been called warty teeth—teeth which present nodules or excrescenses projecting from some part of the surface. The excrescences most frequently spring from the neck of the tooth below the gum, and occasionally they assume the appearance of a supernumerary tooth lying in contact with the tooth to which they are attached. Section of these outgrowths shows them to be composed of dentine coated with enamel, and they sometimes contain a pulp cavity continuous with that of the tooth. The roots of warty teeth are often well-formed, but in some cases, especially where numerous excrescences exist on the crown, the root is stunted and ill-formed. In these cases, along with hypertrophy of the tissues of the crown, there appears to have occurred arrest of development of the root.

On the other hand, cases sometimes occur in which the crown of the tooth is normal in form, whilst the root is abnormally large, and is composed of a confused mass of dentine and osseous tissue (cement), enclosing a vascular structure, doubtless the hypertrophied dentinal pulp. This subject has already been partly discussed in the chapter on abnormally formed teeth.

Another class of odontome consists of irregular masses of dental tissues mingled without definite arrangement, and bearing no resemblance to a tooth. The mass may not exceed in bulk the tooth whose place it occupies, or it may form a tumour of considerable size.

Still another variety of tumour is mainly fibrous in structure, containing scattered spots of calcification or imperfectly developed dental tissues.

Odontomes are usually either cystic or encysted, the latter variety having no attachment to the surrounding structures except such as may have arisen from inflammatory adhesion.

The following is Mr. Bland Sutton's definition:—Odontomes are neoplasms composed of dental tissues in varying proportions and different degrees of development, arising from tooth-germs, or teeth still in the process of growth.

Using as a basis of classification the parts concerned in the formation of a tooth, namely, enamel organ, dentine papilla, and tooth follicle, odontomes are grouped as follows:—

A. ABERRATIONS OF THE ENAMEL ORGAN.

Epithelial Odontomes.

B. ABERRATIONS OF THE FOLLICLE.

1 *Follicular Cysts.*
2. *Fibrous Odontomes.*
3. *Cementomata.*
4. *Compound Follicular Odontomes.*

C. ABERRATIONS OF THE PAPILLA.

Radicular Odontomes.

D. ABERRATIONS OF THE WHOLE TOOTH-GERM.

Composite Odontomes.

Aberrations of the Enamel Organ.—*Epithelial Odontomes.*—These tumours are usually composed of a congeries of small cysts rarely over an inch in diameter, filled with mucoid fluid, separated by thin septa mostly fibrous but sometimes osseous.

In typical specimens the tumour displays on section a congeries of cysts, in size very various.

Histologically, these tumours are principally composed of branching and anastomosing columns of epithelium. The stroma is composed of fibrous tissue.

The naked-eye appearance of these tumours, well displayed in fig. 121, is very characteristic.

Aberrations of the Follicle.—*Follicular Odontomes.*—In this category Mr. Sutton includes dentigerous cysts, but as the term has been loosely applied to any cyst which bears teeth, even ovarian dermoids, he styles those connected with teeth *follicular* cysts or odontomes.

Fig. 221.

They arise in relation with teeth which have remained within the jaws—buried teeth, described in an earlier chapter. They are most frequently connected with molars. In the upper jaw the cyst may invade the antrum.

A glance at the relation of a tooth to its follicle will explain that if fluid accumulates between the tooth and follicle a cyst will be formed, and its size will depend upon the amount of fluid. Sir J. Tomes first suggested that follicular cysts are due to the excessive formation, around a retained tooth, between the enamel and the

wall of the follicle, of the fluid which, small in quantity, is normally found after the complete development of a tooth.

The thickness of the walls is very various, in some thin and crepitant, in others measuring half an inch or more. The contained teeth are often ill-developed. Sometimes the crown is well-formed, but the fang is imperfect or truncated as in the bicuspid in fig. 222, which represents a typical follicular cyst laid open. In a few specimens the tooth is loose in the cavity; occasionally it is inverted and not infrequently wanting.

FIG. 222.

The following case, with the illustration taken from Mr. Heath's work* will serve to exemplify the common course and history of dentigerous cysts, and also to make evident the importance of the rule that in cases of doubtful diagnosis the nature of tumours of the jaws should be put beyond question by incision and exploration before further operative procedures are undertaken.

In this case the cyst occurred in the lower jaw, and gave rise to a general expansion of the bone rather than a distinct tumour, but the disease was mistaken for a solid tumour. The patient was a girl aged thirteen. The tumour was large and resistant, occupied the left

* Injuries and Diseases of the Jaws, third edition.

side, and had been growing six months. No opening could be detected, though there was a constant offensive discharge from the surface. The surgeon in charge of the case removed the left half of the jaw, from the symphysis to the articulation. The tumour (fig. 223), gave exit to a quantity of fœtid pus on being opened, and it proved to be a bony cyst formed by expansion of the two plates of the jaw. The cavity was lined with a thick vascular membrane, and at the bottom the canine tooth was seen projecting from the wall. The case was evidently, therefore, one of dentigerous cyst due to the non-development of the canine tooth, the contents of which had from some cause become purulent. A cyst of

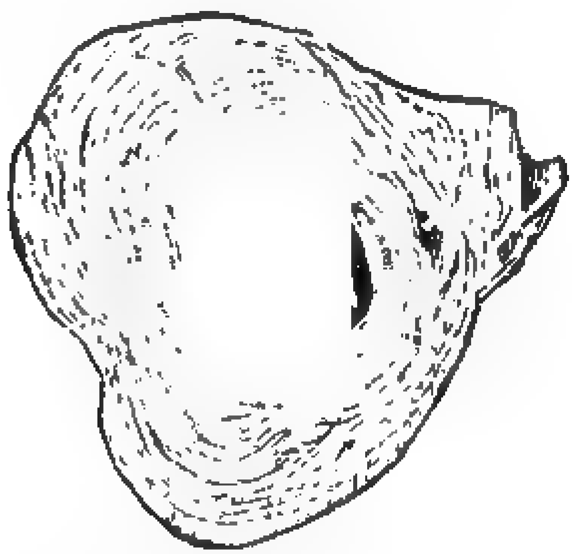
FIG. 223.

this kind may, of course, develop in the case of any embedded tooth. Examples of this abnormality were illustrated in a previous chapter.

Fibrous Odontomes.—These growths Mr. Sutton traces to hypertrophy of the tooth sac the capsule of the developing tooth. Under certain conditions this capsule becomes greatly increased in thickness and so thoroughly encysts the tooth that it is never erupted. Such thickened capsules are often mistaken for fibrous tumours, especially if the tooth is small and ill-developed. Under the microscope they present a laminated appearance with strata of calcific matter.

Mr. Sutton considers there is good reason for the belief that rickets is responsible for some of these thickened capsules. It has long been known that in rickety children the teeth are late in appearing, and several years ago he pointed out that the delay might be attributed to abnormal thickness of the follicle. That the tooth sac should thicken in rickety children is borne out by the fact that this disease affects most particularly membranes engaged in the production of bone; and specimens are preserved in the museums which further

FIG. 224.



support this opinion. Fig. 224 clearly shows the structure typical of this class of odontome.

In fibrous odontomes there is found a well-formed tooth, although odontomes are usually devoid of all resemblance to teeth, so far as shape is concerned. In the upper jaw odontomes often have a well-shaped tooth attached to them, as in Hare's case (see fig. 230); in the lower jaw they mostly consist of a conglomeration of dental tissues. This difference Mr. Sutton explains by the anatomical differences of the jaw bones. In the upper jaw odontomes invade and grow freely in the

antrum, and attain a far larger size than is possible between the two resisting plates of the lower jaw.

Cementomata. -When the capsule of a tooth becomes enlarged, as in the odontomes just considered, and this thick capsule becomes ossified, the tooth will become

FIG. 225.

embedded in a mass of cement. To this form of odontome the name cementoma is applied.

Among classical odontomes, the most typical specimen, which illustrates well the characters, macroscopical and microscopical, of a cementoma is that recorded by Dr. Forget from the lower jaw of a man aged forty. Before

FIG. 226.

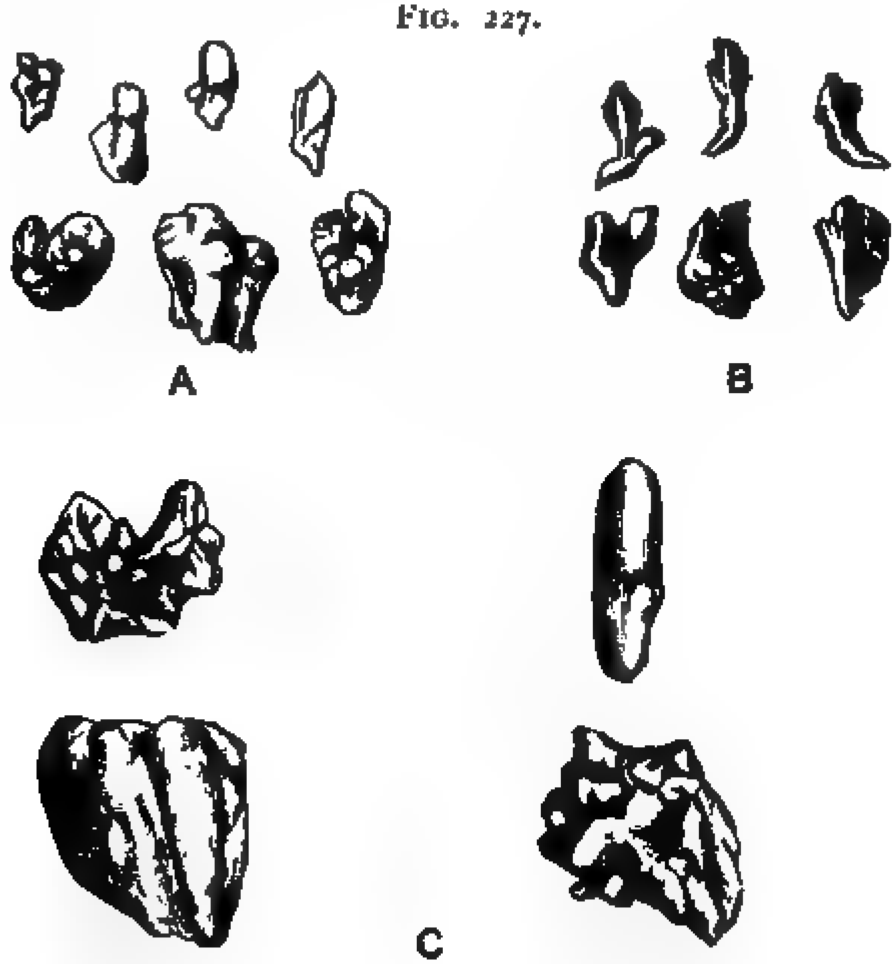
operating on the tumour, it was determined to extract a decayed molar, and the odontome came away with it. Under the microscope the tumour, which was of the size of a pigeon's egg, consisted of cement only (figs. 225 and 226). Broca gives a drawing representing a vertical section through this odontome. The shape, disposition,

and structure of this odontome plainly show that it had its origin in an overgrown, ossified, dental follicle.

Compound Follicular Odontomes.—Mr. Sutton accounts for these growths on the supposition that they are derived from a thickened capsule which has ossified sporadically instead of *en masse*. The tumour will then contain a number of small teeth or denticles consisting of cement, or dentine, or even ill-shaped teeth composed of three dental elements, cement, dentine, and enamel. The number of teeth and denticles in such tumours vary greatly, and may reach a total of three or four hundred.

Tumours of this character have been described by several observers. Amongst the most noteworthy may be mentioned the following:—

FIG. 227.



Tellander, of Stockholm, met with a case in a woman, aged twenty-seven years. The right upper first molar, bicuspids and canine of the permanent set had not erupted, but the spot where these teeth should have been was occupied by a hard, painless enlargement, which the patient had noticed since the age of twelve years. Subsequently, this swelling was found to contain minute teeth. There were nine single teeth, each one perfect in itself, having a conical root with a conical crown, tipped with enamel; also six masses built up of adherent single teeth. The denticles presented the usual characters of supernumerary teeth. About a year afterwards a tooth was found making its appearance in the spot from which the host of teeth was removed. A few of the teeth are represented in the group A in fig. 227.

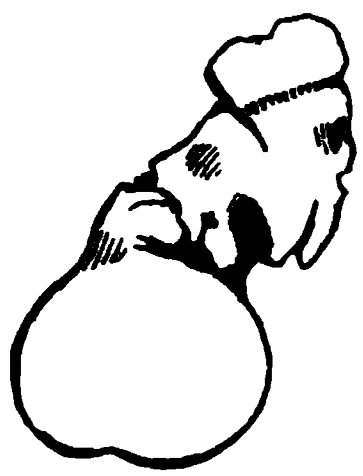
A similar case has been recorded by Sir John Tomes, the details of which were communicated to him by Mr. Mathias, whilst on medical service in India. A Hindoo, aged twenty, had a large number of ill-formed teeth united. Further search was instituted, until at last fifteen masses of supernumerary teeth and bone were removed. The soft parts rapidly healed, the deformity disappeared; the only peculiarity noticeable was the absence of the central and lateral incisors. The canines occupied their usual position. A few of the fragments are shown in fig. 227 C.

A third example of this remarkable condition has been recorded by Professor Windle and Mr. Humphreys. The case occurred in the practice of Mr. Sims, at the Dental Hospital, Birmingham. The tumour occurred in the mouth of a boy, aged ten years. It was found that neither the deciduous nor permanent right lateral incisor or canine had erupted. The space thus unoccupied was filled by a tumour with dense unyielding walls

which occasioned no discomfort. On opening this cyst forty small denticles of curious and irregular forms were removed from the interior. Some of the denticles are represented in the accompanying drawing, fig. 227 B. The largest possessed fourteen cusps. Many were caniniform, with fairly well-formed crowns and roots, the former being covered with enamel. Some resembled supernumerary teeth, while others consisted of several small denticles cemented together.

Radicular Odontomes.—This term is applied to odontomes which arise after the crown of the tooth has

FIG. 228.



been completed, and while the roots are in process of formation. As the crown of the tooth, when once formed, is unalterable, it naturally follows that should the root develop an odontome, enamel cannot enter into its composition, which, for the most part, would consist of dentine and osteo-dentine in varying proportions, these two tissues being the result of the activity of the papilla.

The well-known specimen described by Salter, and represented in figs. 228 (natural size) and 229 (a magnified section), illustrates a typical radicular odontome. In this specimen the tumour is clearly connected with the fangs. The outer layer of the odontome is composed of

cement; within this is a layer of dentine, deficient in the lower part of the tumour; within this is a nucleus of calcified pulp.

Mr. Hare, of Limerick, removed from the upper jaw of a man aged forty-one the odontome depicted in fig. 230. This specimen was originally described by Sir John Tomes in 1863, but it was examined and re-described

FIG. 229.

in 1872 by Mr. Charles Tomes. The mass is invested by cement; inside this casing is a shell of dentine, the tubes radiating outward and disposed with some regularity. This dentine was deficient at the distal end of the tumour; its interior was filled with an ill-defined osseous material.

Aberrations of the whole Tooth-germ.—*Composite Odontomata.*—This is a convenient term to apply to those hard tooth tumours which bear little or no resemblance in shape to teeth, but occur in the jaws, consisting of a disordered conglomeration of enamel, dentine, and cement. Such odontomes may be considered as arising from an abnormal growth of all the elements of a tooth-germ—enamel-organ, papilla, and follicle.

Not only is this class of odontomes composite in that the tumours comprised in it originate from all the elements of a tooth-germ, but they are composite in another sense. In the majority of cases the tumour is

FIG. 230.

composed of two or more tooth-germs indiscriminately fused. But they differ from the cementomata containing two or more teeth from the fact that the various parts of the teeth composing the mass are indistinguishably mixed, whereas the individual teeth implicated in a cementoma can be clearly defined.

Forget's well-known case is placed by Mr. Sutton in this class. The patient, a man aged twenty, had suffered with disease of the lower jaw since he was five years old. Upon looking into the mouth, a round, smooth tumour, hard and unyielding, was seen occupying nearly the whole of the left side of the jaw. None of the teeth, beyond the first biscupid, were

present. The portion of jaw shown in the engraving (fig. 231), was removed by operation by M. Forget, under whose care the case came. Examination of this portion showed that the jaw between the first bicuspid and the ramus was converted into a cavity occupied by a hard, oval mass of the size of an egg, having an uneven surface covered here and there with minute tubercles invested by a layer of enamel. Section and microscopical examination proved the tumour to consist of

FIG. 231.

dentine with enamel on the surface and dipping into crevices, at the bottom of which, as well as in other parts, portions of cement were found. Between the tumour and osseous walls enclosing it was a thick membrane of a fibro-cellular structure. M. Forget regarded the case as one of fusion and hypertrophy of the last two molars.

At the date of the occurrence of this tumour (1855) the exact nature of growths of this kind had not been clearly ascertained, and hence excision of a portion of

the jaw was performed, instead of enucleation of the tumour, which evidently would have served equally well for the cure of the disease.

The letters *a* and *b* indicate portions of the tumour projecting through the bone; at *c*, where the enclosing bone is cut away, the crown of an inverted molar is seen lying between the tumour and the jaw; *d* is the second bicuspid lying beneath the first, *e*.

It is supposed that odontomes are more frequent in the lower than the upper jaw, but there is good ground for the belief that many such tumours have been erroneously described as exostoses of the antrum.

The strange specimen illustrated, fig. 57, on page 102, described in the chapter on supernumerary teeth, serves to bridge the gap between what Mr. Sutton styles compound follicular cysts and composite odontomes.

Treatment.—Odontomes do not necessarily give rise to irritation or disease, and the variety in which the morbid changes are confined to the root may, on the contrary, remain in position for years, serving the purpose of a tooth. Should they, however, constitute a deformity, become a source of irritation, or the centre of inflammatory action, they must be removed. Their extraction can be accomplished in some cases by means of an ordinary tooth-forceps, and, should it be necessary, the bone may be divided by bone-forceps to facilitate the operation. The fibrous variety may be removed by similar means. The cyst having been laid open, the mass may be turned out with the handle of a strong scalpel or with a gouge or elevator.

The treatment of cysts of the jaw, classed by Mr. Sutton as follicular odontomes, consists in laying them open freely, in removing teeth when these are contained within, and plugging the cavity so as to destroy the secreting surface. The incisions ought to

be made within the mouth when possible, so as to avoid subsequent deformity.

It cannot be too strongly insisted that in all cases of tumour of the jaw of doubtful diagnosis exploratory incisions—within the mouth if possible—ought to be made to ascertain the true character of the disease, before a formidable operation like excision of the jaw is proposed. An operation of this magnitude and severity was—as we have seen—not infrequently performed for the removal of odontomes in former times before the real nature of these growths was recognised.

Cystic Growth from Roots of Teeth.—Attached to the roots of teeth may often be found cysts, varying in size but generally not much larger than a pea, and almost always in connection with septic pulps. These small root tumours have been shown by Mr. Turner* to have a distinct epithelial lining. This epithelium is derived, according to this observer, from the sheath of Hertwig—a structure described in the chapter on development of the teeth. By a continued growth at the periphrey of these epithelial remains and a degeneration in the centre a small cyst is in time found containing a pultaceous mass like inspissated pus. The contents may liquify and with the continued growth of the epithelium a cyst may be formed which when of any size determines for itself a connective tissue capsule. The growth of the cyst seems to be induced by the presence of septic matter derived from a dead pulp.

Malignant Disease of the Peridental Membrane.—Mr. Hopewell Smith has described † examples of new growth intimately associated with and springing from the fibrous periosteum of the teeth. A tumour of the round celled sarcomatous variety had previously been

* Journal Brit. Dent. Assoc., Oct., 1889.

† Lancet, July, 1895.

described, but Mr. Hopewell Smith's work on this subject may be looked upon as original. He suggests that the chief points of interest in connection with these peridental tumours are that they are found in connection with the roots of sound teeth and that their characteristics are those of round-celled sarcomata. They appear to affect most commonly the upper teeth of the molar series and to spring from the point of junction of the root with the body of the tooth, or from one or two roots, eventually filling up the whole of the inter-radicular region of the tooth. The tumours are described as varying in size from that of a pea to a small nut, but never apparently growing to a very large size. The teeth themselves are loose and painful, the pain being described as at times excruciating. The growths consist microscopically of masses of cells embedded in a matrix of fine connective tissue; vessels ramify among the cells. The cells are principally of the round-cell variety, but spindle cells are also found. It is very unlikely that a diagnosis will be made in these cases until the tooth is removed, but in any case extraction will be called for owing to the pain; microscopic examination of the growth will then make clear the nature of the disease.

Epulis is a tumour, either fibrous or myeloid in character, attached to and springing from the maxillary periosteum. It generally commences between two teeth, which become gradually pushed apart and loosened; but it sometimes springs from a part of the bone distant from the teeth. It grows slowly and painlessly, forming a firm, rounded, often lobulated mass, covered with mucous membrane. The fibroid variety commonly ossify, the deposition of bone progressing from the point of attachment towards the surface. A case of epulis in its simplest form is shown in fig. 232 from Mr. Heath's work. If neglected epulis sometimes reaches an

enormous size, encroaches upon the cavities of the nose and eye, and produces great deformity. In the later stages it may ulcerate, and frequent hæmorrhages taking place, the growth closely simulates malignant disease. Epulis is believed to be due in some cases to irritation of decayed teeth or to injuries of the alveoli, such as sometimes occur in extracting teeth, but in most instances the tumour cannot be clearly traced to these causes. Mr. Henry Sewill met with several cases in which a small fibrous tumour, identical in structure with epulis, in size between a pea and a spanish nut, was found attached and springing solely from the periosteum

FIG. 232.

of a decayed tooth and having no attachment either to the gum or maxillary periosteum. Some specimens were presented to the Odontological Society. These cases suggest a possible origin of larger growths.

The Treatment consists in cutting out the tumour, together with the portion of bone from which it springs, and from which, if allowed to remain, it would probably again grow.

Osseous Tumours, or exostoses of the jaws, are occasionally met with. The most common situation of exostoses is on the inner surface of the lower jaw, where they form hard, round, smooth protuberances. They sometimes spring from the angle, and they may also

grow from the neighbourhood of the antrum and other parts of the upper jaw. Osseous tumours are slow in growth and painless, and are not commonly developed to such an extent as to cause inconvenience. Their cause is obscure, but in some few cases they would appear to be associated with persistent irritation—chronic periostitis—spreading from the teeth. There is evidence that these tumours are sometimes due to ossification of growths originally cartilaginous in structure.

The treatment is excision of the tumour, which may be called for if the growth becomes a source of deformity or inconvenience.

DISEASES OF THE ANTRUM.

Acute Inflammation.—The roots of several teeth are separated from the cavity of the antrum by merely a thin layer of bone—sometimes the roots of the first and second molars pass within and are covered only by a thin osseous film beneath the mucous membrane. From this anatomical condition it might be supposed that inflammation of the antrum would form a very frequent accompaniment or sequela to periodontitis affecting the neighbouring teeth; but it is by no means common.

The symptoms of acute inflammation are throbbing pain, with great swelling of the cheek, accompanied by more or less feverishness. If the disease runs on, the pain becomes more severe, extending to the nose and frontal sinus, and an erysipelatous blush appears on the skin. The gums are red, spongy, and swollen, and when suppuration occurs there is a discharge of pus from the nostril of the affected side, either when the patient inclines his head forward, and towards the sound side, or when he blows his nose; and pus may flow down the throat when he assumes a horizontal position. The formation of pus is attended by rigors. If the matter find vent through the natural opening into the nose the pain and other symptoms may subside, but if it do not find an exit the symptoms persist, and the walls of the antrum become distended. The walls may bulge outwards at their thinnest parts,

or, encroaching upon the neighbouring cavities, may occasion pressure upon the contents of the orbit, with protrusion of the eyeball, closure of the lachrymal duct, and blocking up of the nostril. These complications have arisen in neglected cases.

Acute inflammation of the antrum, except in its severest symptoms, resembles some cases of dental periostitis, and it is indeed often merely an extension of that disease from the periosteum of roots to the contiguous lining membrane of the cavity.

Inflammation of the antrum may also be caused by extension of inflammation from other contiguous nasal accessory cavities. It may also arise from injury to the bone, as from a blow on the face or in extraction of teeth, or may be due to the presence of a foreign body such as a tooth fang, which in an attempted removal has been forced into the cavity.

Differential diagnosis between acute inflammation of the antrum and dental periostitis and alveolar abscess is easy. In inflammation of the antrum the symptoms are not visible externally until they have advanced, whilst in alveolar abscess they are visible from the first. The swelling in the dental disease begins on the outside of the wall of the antrum, and afterwards involves the cheek. The progress of the swelling can be watched; or if seen only in an advanced stage, the abscess, a fluctuating swelling over the bone perhaps pointing, is unmistakable. In acute suppuration within the antrum the pus would press towards the most yielding wall. In the vast majority of cases it would find vent through the natural opening into the nose; very rarely, if ever, would it penetrate the outer plate of bone and discharge in the situation of alveolar abscess.

Treatment.—The exciting cause must be removed, whether it be a root lodged within, or a decayed tooth

in the neighbourhood of the cavity. The extraction of the tooth will often be followed by subsidence of the symptoms, the matter, if suppuration have occurred, escaping through the alveolus. If the matter do not freely escape, the opening may be enlarged by pushing a trocar through the bone at the apex of the alveolus. This operation must be followed by warm fomentations and repeated injection of warm water into the cavity. If the discharge continue after subsidence of the acute symptoms, antiseptic lotions may be thrown into the cavity.

It must be remembered that the internal surfaces of the antral floor and walls are not plane and smooth. They are always more or less broken up and divided by ridges of bone and folds of mucous membrane, so that often there are formed crypts or pouches in which a foreign body is apt to lodge, and in which pus is apt to accumulate and to become inspissated. A root of a tooth having been forced in during an attempted extraction may thus not be easy to find and remove. It has been necessary in some cases to search the antrum with a silver probe, with a thin shaft capable of being bent to any curve or angle, and having a small saucer-shaped end with which to sweep the interior. If necessary the opening must be enlarged with a trocar; in some cases it might be possible to expel a foreign body through the opening into the nose by means of a strong current of water thrown through the cavity from the alveolus, the patient's head being meanwhile inclined forward and to the opposite side.

Empyema.—Judging from the experience of the Editors of this Manual the subject of empyema of the antrum is of greater importance, if not of greater interest, to the medical than the dental practitioner, for though they have tapped the cavity in a number of

cases, now very large, in comparatively few instances has a patient applied directly to them as dental surgeons. In those which have applied directly, the patients have usually complained only of trouble connected with the teeth.*

In one case following an attack of influenza, the patient, after severe toothache in a bicuspid, gave a history of periodontitis, followed by suppuration and abscess, which had burst and discharged through the nose. On removal of the tooth, the antrum was found to contain pus. In another, in which there was not free escape for the pus through the ostium, distention of the cavity had caused absorption of its outer wall, and the patient sought advice with regard to a soft fluctuating swelling over the first upper molar. The great majority of cases have, however, been brought by medical practitioners, by whom a diagnosis had been made; but in many of them the patients had suffered for months, some for years—often undergoing treatment wrongly directed—before the real nature of the malady had been made out.

Until comparatively late years, when the subject has been fully dealt with by Zuckerkandl, Ziem, Krause, Semon, and other writers, our knowledge of antral empyema has remained far from complete, and the existence of the disease does not appear even now to be fully recognised either among dental or medical practitioners. It is only within the last thirteen years that cases have been commonly treated. The affection does not seem to have been clearly described by many older writers, although Allouel and Jourdain, in the last century, recognised the disease, and even effected cures

* The Editors during the past twelve years have tapped the antrum, and constructed the drainage apparatus presently to be described, on an average, in twelve cases annually.

by syringing through the maxillary ostium. Text-books have, until recently, given no clear or adequate description of the disease. As the etiological factors which give origin to it surely existed formerly as they do now, it can only be concluded that until the present day the true character of the disease has been overlooked.

The fact that dental disease is among the most common causes of this affection, and that the services of the dental surgeon are in many cases almost indispensable in its treatment, render the subject of importance to every dental surgeon.

Etiology.—First, as to etiology. The roots of several teeth, notably the second bicuspid and first and second molars, are separated from the cavity of the antrum by merely a thin layer of bone. Sometimes roots pass within, and are covered by a thin osseous film beneath the mucous membrane. From this anatomical condition it is easy to perceive that there must exist a danger of extension of inflammation from around teeth, or of septic matter or pus, the products of dental disease, flowing in; and that this does occur in a certain proportion of cases, and that the result is to establish an empyema, seems beyond doubt. It is worth while noticing in passing that antral empyema seems, in most instances, due to chronic disease—at least, comparatively few cases are met with in which evidence of, or history of acute inflammation of the cavity was to be discovered. The vast majority of cases of empyema of the antrum are chronic from their commencement. There is very often a history of acute dental troubles—inflammation of pulp or periosteum, or both—but although some cases have followed at once upon an acute dental attack, it has generally been clear that the acute symptoms had subsided before, often long before, symptoms of pus in the antrum became fully developed.

An acute alveolar abscess may burst into the antrum; and if the tooth be not extracted for the relief of the urgent symptoms, it may remain with necrosed roots the centre of chronic suppuration. The pus from an abscess caused by necrosis is most highly septic and irritating; and the effect of such a discharge long-continued might be to infect and cause suppuration from the whole lining membrane of the antrum.

In most cases either the history of dental disease is clear, or a diseased tooth is present, which demonstrably constitutes the exciting cause. Cases are not often seen where all the teeth in the affected side are perfect, and where there is no history of dental trouble in that portion of the maxilla. One case was seen in which, although dental disease (a carious bicuspid with exposed pulp) was present, it was certain that simple inflammation only, not running on to suppuration, had occurred within and without the tooth. It cannot be believed that any dental disease not giving rise to direct septic or purulent infection can originate antral empyema. There is no difficulty in understanding how inflammation beginning in another accessory cavity of the nose may spread to the antrum, and, localising itself there, may lead to empyema, and a proportion of cases is ascribed to this cause. But in the case in question a most careful differential diagnosis by Sir Felix Semon had eliminated every possible cause but the tooth, and thus the etiology of this case remained in doubt.

Pathology.—The pathology of empyema seems simple. Pus once present, and secreted in the antrum, the cavity can never be perfectly emptied except by art. Pus flows out when it reaches the level of the ostium—the natural opening into the nose—or when the head is inclined forwards, but owing to the height of the opening, and its direction, a residuum always remains on the floor,

and this becoming putrid, and often inspissated, irritation is increased, until at length the whole lining of the cavity becomes involved, and a condition is established to which the term empyema may fitly be applied. It is worth while mentioning here that the ostium may vary within considerable limits in point of size. It may be almost impervious, or it may be sufficiently large to allow of the passage of a piece of gum elastic catheter, size No. 8. Smaller accessory cavities may exist in the antrum when bony septa divide the cavity into several divisions.

Symptoms.—The symptoms consist of discharge of pus, mostly fœtid, from the nostril of the affected side; and pain. Be it noted, the discharge, besides being unilateral, is not continuous, but occurs at irregular intervals, *i.e.*, when the antrum is full, and particularly when the head is inclined forwards. In recumbency discharge may flow down the posterior nares. The patient is conscious of a noisome odour—the pus is often remarkably offensive—but the odour is not usually perceptible to others, except at the moment when pus may be flowing from the nose.

The pain may be quite local, and then it is dull and aching in character, or it may, and often does, take the form of severe frontal headache and neuralgia. It appears not an uncommon belief that distention of the antrum and bulging of the walls form usual symptoms of empyema, but this is a mistake; these symptoms occur only in those rare cases in which the ostium is quite occluded. This is seen in only a few instances. In one case of this kind the patient had suffered most from pressure beneath the orbit, and ophthalmic troubles in consequence. In another a prominent symptom was bulging of the external wall of the antrum simulating a growth springing from within.

The amount of mental depression and injury to the general health are often much greater than would seem possible in these cases. The quantity of fœtid pus, which must at night drain into the stomach, must not be overlooked in considering effects upon the general health. In several instances blotches and herpetic eruptions on the face and round the mouth have rapidly disappeared on free drainage of the antrum being established.

Diagnosis.—The diagnosis of empyema of the antrum is not generally difficult. A patient presenting the principal symptoms mentioned will, in all probability, prove to be a sufferer from this affection; but it is not always safe to pronounce a positive diagnosis without thorough rhinoscopic examination. Mistakes have been made and recorded by very competent observers, and the antrum has been opened in several cases in which no antral trouble had been really present. The relative transparency of the cheeks on transillumination by means of a small electric lamp within the mouth is not always a reliable sign. Presence of pus is not invariably denoted by the opacity of one side. But the amount of light transmitted through the infra-orbital plate seems to afford a more certain sign. Sir Felix Semon employs a diagnostic method which he considers almost conclusive. The nasal cavities are first cleansed and then the patient is made to lie down with the head dependent, but with the side uppermost on which the empyema is believed to be. Pus in the middle meatus then can only be derived from the antrum, *via* the opening into the nasal fossa.*

* In the "Laryngoscope" for February, 1901, Dr. D. A. Kuyk, calls attention to the use of the tuning-fork in cases of antrum disease where the diagnosis is obscure. By testing with the fork over the antrum and first and second molars, if the antra are free and clear the tuning-fork will be heard with equal distinctness and for a like duration over each side and in either location. If one antrum contains fluid the fork will not be heard so distinctly.

Disease of the frontal sinus, or of the ethmoidal cells, and presence of nasal polypi or adenoid growths, may complicate the malady or give rise to symptoms closely simulating antral empyema.

It seems probable that in some cases nasal polypi are caused solely by the irritation of the discharge from the antrum.

In some cases pus in the antrum is derived entirely from the frontal sinus. It finds its way there through anatomical canals in the bones connecting the cavities.

Treatment.—The treatment consists in removing irritating causes, whether in the teeth or elsewhere, in providing free drainage, and in thorough irrigation of the cavity with antiseptic lotions. It would probably be safe to lay down a rule that any tooth in a condition in which it may be only open to suspicion as the cause of empyema ought to be extracted. This opinion is based upon experience of cases like the following. In this case disease of the antrum had been suspected, and frequent enquiry made into the condition of the teeth by surgical practitioners who had been consulted. They had, however, remained satisfied on the patient's assurance that his teeth were in good order, and had been pronounced free from disease by a leading dentist. At length a positive diagnosis of empyema was made by Sir Felix Semon. The first molar of the affected side contained a large amalgam filling, evidently extending into the pulp cavity, and the pulp was dead. The tooth was free from pain, not notably sensitive to percussion, and displayed no well-marked sign or symptom of internal or external inflammation. It had been decided from the

perhaps faintly, perhaps not at all; if the opposite antrum is free the patient replies quickly and positively in the affirmative. The author notes that the same method may be applied to cases of frontal sinus disease, and perhaps ethmoid disease, and certainly it is of use in mastoid disease.

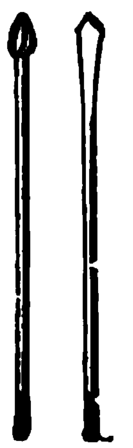
first that the antrum should be tapped through a socket even if a sound tooth had to be sacrificed; and the molar was therefore extracted. On opening the tooth it was found that the pulp had been removed, and the tooth filled *secundum artem*, but the palatine root was extensively necrosed from the apex downwards, and its alveolus communicated with the antrum by an opening large enough to admit an ordinary dressing-case silver probe. Suppuration round this root had found free vent into the antrum, and hence tension within the socket, and symptoms referred to the tooth were absent. So much pain in this case had been suffered in the form of neuralgia and headache that it would have been with difficulty localised by the patient; and ophthalmic symptoms from pressure beneath the floor of the orbit had existed, which further confused diagnosis.

Probably a majority of surgeons prefer to drain the antrum through the alveolar border. The only other opening worth considering is through the canine fossa, and that only when it is deemed advisable to scrape the antral membrane or plug the cavity. The objection to this opening is that it takes a long time to close, and sometimes never does so. Almost all surgeons in England, at least, are performing the operation of opening through the alveolus, but elsewhere opening through the nose, as advised by Krause, is in many cases preferred. The various points through which openings can be made are: (1) Inferior or middle meatus of the nose; (2) Canine fossa; (3) Zygomatic fossa; (4) Alveolus.

What is principally called for is free, constant drainage. This effected, the longest step towards a cure is achieved, and immediate relief to all urgnet symptoms is in most cases afforded. Tapping may be

performed through the alveolus of the first or second bicuspid, or first or second molar; when the latter, a buccal socket should be chosen, so as to avoid missing by accident the antrum and perforating the floor of the nose, and so as to leave the opening in the bone as vertical as possible. The opening should always be made as nearly as possible at right angles to the plane of the alveolar border, else when making the drainage apparatus, presently to be described, it is much more difficult to secure the tube accurately in relation to the plate when removing it from the mouth before finally soldering these two parts together.

FIG. 233.



For making the opening the dental engine may be employed, with a spear-headed drill, shown half actual size in fig. 233, of about one-eighth of an inch in diameter, and of sufficient length to penetrate the antrum, but not long enough to endanger the floor of the orbit. The nozzle of the hand-piece of the engine also acts as a stop in case of a sudden plunge on the part of the patient. The opening is then enlarged by a trocar (fig. 234, half-size), to allow the passage of a tube of at least one-eighth of an inch in diameter; and the trocar is held so that the thumb acts as a stop to prevent it by accident penetrating too far. Cases are on record where

the outer, inner, and posterior walls have been injured or penetrated by the trocar.

The dental engine is not absolutely necessary in the operation; those who prefer it may find small trocars sufficient for all purposes. It is useful to bear in mind the accidents which may occur during the performance of the operation of tapping the antrum. They are as follows: Failure to reach the antrum, the cavity varying at times in position and size; and it being often difficult exactly to estimate the depth of the alveolus through which the perforation is to be made without careful probing and measurement. As before mentioned, the orbital plate may be wounded; any of the walls of the antrum may be wounded. Zeim records a case of

FIG. 234.

retro-maxillary abscess and secondary abscess in the cheek following penetration of the posterior wall of the sinus. A branch of the infra-orbital artery has before now been wounded, and the writer quoted above records a case where ligation of the infra-orbital artery became necessary from a similar cause. The possibilty of wounding the floor of the orbit must *always* be borne in mind, but this accident seems barely possible with exercise of proper care.

Fig. 235 shows a cast of a case with the opening through the alveolus.

Nitrous oxide gas is the best anæsthetic in these cases; and when a tooth has to be first drawn the operation may be divided into two parts, but may be carried out in one sitting. First the tooth is removed, and the patient having recovered, an examination is

made, and it is decided through which socket the antral opening may best be made. The patient is now again narcotised, and the operator, standing ready, drill in hand, and engine revolving, perforates the cavity, and then with the trocar at once enlarges the opening to the

FIG. 235.

desired extent. For this procedure "gas" narcocis affords time enough; indeed, in many cases it is possible to extract a tooth and tap the antrum in one operation. In most cases flow of pus, often very offensive, follows withdrawal of trocar; in some instances the pus is inspissated and does not appear

FIG. 236.

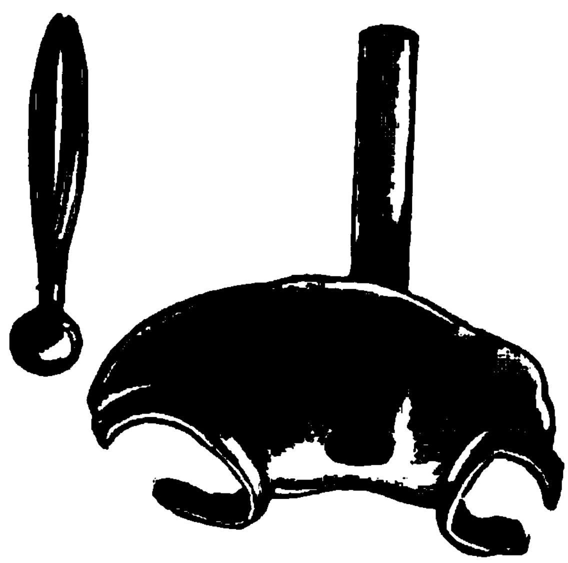
until a stream of water is thrown in. During subsequent manipulations in patients who do not bear slight pain well, the passage may be mopped with a saturated solution of cocaine carried on a fine wire probe bound with absorbent cotton.

In order to keep the opening patent during the making of a drainage apparatus a silver tube of appropriate size must be inserted. The tube, fig. 236,

is made in the central portion of thick coiled silver wire to render it flexible. It is generally easily retained in position, but if necessary must be tied to adjacent teeth.

Large experience has proved that the best apparatus for keeping the opening patent, preventing growth of granulations, and facilitating drainage and syringing, consists of a plate such as is usually made to carry an artificial tooth, but fitted with a gold tube to pass within the antrum, fig. 237. The plate being made and found perfect, a hole is cut corresponding to the opening into the antrum; and the tube fixed in position with modelling composition is tried in, so as to secure accuracy of adaptation. The

FIG. 237.



main point is to ensure easy passage of the tube, and to guard against irritation from pressure upon the bony passages or walls. During trials it is necessary to secure the tube by means of a ligature passed through a hole drilled in its lower extremity, lest the tube slip and pass within the antrum. The tube having been carefully withdrawn in position is soldered to the plate in the usual way. If the patient be wearing artificial teeth, the tube may sometimes be adapted to the denture. The tube has a rounded open end above, and opens below by a funnel-shaped orifice, which may be kept when

necessary, as during meals, plugged with a gold split pin. It is well for the first few days not to close the tube at all. The total length of the tube is usually three quarters of an inch or more. The depth of alveoli varies greatly, and it is necessary for the tube to project well into the antrum, as otherwise the mucous membrane may close over the opening if the end of the tube is only just level with the antral floor, and block the opening, and thus the patient will be unable to syringe properly. The plate should be removed frequently for cleansing. It

FIG. 238.

will be found that pus escapes freely by the sides of the tube when plugged, and it is not necessary to perforate it with holes. Fig. 238 shows the cast of a case with the plate *in situ* and the tube closed by the split pin.

Drainage being thus provided for, the antrum, after being freed by syringing from inspissated pus, must be thoroughly irrigated twice a day with an antiseptic lotion, such as chloride of zinc, half a grain to the ounce, perchloride of mercury, 1 in 4,000, or other antiseptic of equal strength. In chronic cases considerable benefit often results from occasional changing of the antiseptic.

The syringing apparatus devised by Mr. Christopher Heath, fig. 239, with the addition of a bayonet joint to fix the canula to the nozzle, answers best. It is provided with a long thin nozzle to pass well up the tube, and worked by an elastic ball action. It is capable of throwing a continuous stream of just the right strength through the cavity. Half a pint of lotion may be used at each sitting. The lotion should make its exit through the nose, the patient's head being inclined forward. The tube may be withdrawn during syringing, if the patient finds it more convenient. This treatment is continued until a cure is accomplished, when the tube is discarded, and the opening allowed to close.

In cases where the opening is large, it is sometimes well to cut off the tube, solder up the orifice, and let the plate be worn until the opening has healed.

For the first week or so the cavity should be syringed out morning and evening as long as pus exists in any quantity; and the injection should be stopped on each occasion as soon as the lotion runs clear. Afterwards, when only a small quantity of pus is secreted, washing out once a day will be sufficient, and as pus decreases, every other day only. Care should be taken when no pus appears to syringe out only two or three times weekly. The opening should not be allowed to close until at least six or eight weeks after the last appearance of pus.

In all cases it is absolutely necessary that the injections shall pass from the alveolar opening through the ostium and flow out from the nose. In cases where it does not, either the adjustment of the tube may be at fault, or the opening may be blocked with inspissated pus. In the latter case, blowing the nose violently, and carefully syringing, will usually clear the way. The

ostium may be blocked with hypertrophied membrane, in which case it must be removed by the surgeon.

FIG. 239.

Cases of empyema are often extremely chronic, and they usually resist treatment for periods proportionate to the time the disease has lasted. Recurrence after apparent cure is not common, but cases have been observed, especially after influenza, which tend to show that relapse may occur. Cases in which both antra contain pus, are met with not rarely, but they call for no special remark, either as regards etiology or treatment.

Whilst care must be taken to ensure thorough drainage, the danger of keeping up irritation by too much syringing, and the use of unsuitable lotions, must not be overlooked.

To attempt a complete diagnosis in empyema of the antrum is not within the province of a dental surgeon. This can be done only after full rhinoscopical examination; and it is only such an examination that can determine the absence or existence of the complications which have been referred to. The pus may, as already mentioned, be derived from the frontal sinus, or from some other neighbouring cavity the real seat of disease.

In treatment the dental surgeon's part seems to lie in the extraction of teeth which may be called for, in tapping the cavity, and in construction of a drainage apparatus. The further conduct of the case, including prescription of antiseptic irrigation, seems to belong to the surgeon.

Tumours of the Antrum.—The antrum is sometimes the seat of dentigerous, cystic, fibrous and other tumours, which call for few special observations here after the general remarks upon morbid growths of the maxillæ which have been made in a previous chapter.

An occasional sign of tumour of the antrum is

protrusion or displacement of the molar teeth. To establish a diagnosis, it is often a good plan to extract one of these teeth and explore the antrum through the alveolus. In this way the character of a morbid growth in an early stage may sometimes be detected—a matter of extreme importance where the tumour is of malignant nature. In one instance (reported by Mr. Sewill in the *Transactions of the Odontological Society*) this procedure led to the discovery of a cancerous growth occupying the antrum. A portion of the growth which filled the cavity came away attached to the roots of the first molar, the tooth being quite free from caries, but loose, and protruded from the socket. The upper jaw was completely removed by Mr. Teevan, but the growth recurred immediately and the patient died in hospital. The performance of excision, before the deeper structures have become invaded by a rapidly-increasing tumour, may often be of vital consequence.

TOOTHACHE (ODONTALGIA). NEURALGIA, AND DISEASES OF THE NERVOUS SYSTEM.

Toothache (odontalgia), that is, pain within and around teeth, is merely a symptom, not a distinct disease. It accompanies most of the pathological conditions of the teeth described in previous pages. The most common causes of toothache are caries and its immediate and remote sequels — inflammation of the pulp and periosteum, exostosis and necrosis of roots. Diseased teeth, which perhaps may not themselves be the seat of pain, excite in many instances aching or neuralgic pain in neighbouring or distant teeth, which may be themselves sound. Pain of this kind occurring more or less distant from its source is perhaps most often excited by chronic inflammation of the pulps of carious teeth, and the pain is not infrequently referred to teeth—perhaps sound teeth—of the other jaw. In other cases toothache is caused by diseased roots or impacted wisdom teeth. Facial neuralgia, not arising from dental disease, is commonly accompanied by violent toothache, and in such cases, when proper thought is not given to diagnosis, patients often undergo extraction of many sound teeth which seem the source of pain, without relief to their sufferings. In mouths where there exist either teeth, affected with incipient caries or cavities formed by caries, or surfaces denuded by attrition, toothache—which may have been previously absent or slight—will often begin or increase on occurrence of vitiation of the buccal

secretions, such as, for instance, arises sometimes during the dyscrasia of pregnancy. Treatment of this condition (the first step being free use of antiseptic tooth powders and lotions) has been discussed in previous chapters. Toothache—it must be borne in mind—is in the vast majority of cases due to a local cause, although this is very often not discoverable without careful minute examination of all the teeth. Toothache due to any other than a local cause—although that cause may not lie in the teeth—is extremely rare in childhood and in youthful subjects. It is only on failure to discover a local cause after an examination carried out with extreme care that it is safe to pronounce a case to be one of neuralgia. This subject is discussed in the following paragraphs.

Facial Neuralgia.—The fact is well known that injury and disease of nerve centres, ganglia or trunks, or branches of nerves, commonly manifest themselves by pain at some point distant from, instead of at, the seat of injury or disease. This phenomenon cannot be accounted for, yet, nevertheless, presents itself daily to clinical observation. It may be exemplified by the case of sclerosis of the spinal cord giving rise to neuralgic pain in the lower extremities, an inflammation of the liver giving rise to pain about the right shoulder, a diseased hip-joint producing pain at the knee, and an irritated tooth pulp exciting pain at remote parts of the head and face. Pain of this reflected or sympathetic character is called neuralgia.

The most frequent seat of neuralgia is the region supplied by the fifth cranial nerve; and the most common cause is to be found in pathological conditions of the teeth.

The frequency with which such conditions of the teeth give rise to neuralgic pain is easily accounted for. Each

jaw holds sixteen teeth, and every tooth contains a pulp composed of delicate nerve fibrils, vessels, and cells. This pulp is enclosed within unyielding ivory walls where, unless the chamber be fully opened as a consequence of caries, swelling is impossible, and whence exudations cannot easily escape. Inflammation of the dental pulp is accompanied by tension more extreme than occurs in any other part; and the comparative severity of local pain as well as the frequent excitation of distant pain is thus explained. Although the tension accompanying inflammation around the roots of teeth—periodontitis—be not so exceptional it also is severe, the roots of the teeth being encased within more or less dense osseous alveoli.

In a large proportion of cases of neuralgia no gross lesion involving the nerves, or their ganglia, is discoverable, nor is any pathological change to be found anywhere in the nervous system sufficient to account for the pain. This is particularly the case in the worst form of facial neuralgia — that styled epileptiform neuralgia or tic-douloureux. With the advance of pathology more and more varieties of neuralgic pain are, however, being traced to their true origins; so it seems probable that in time neuralgia, like toothache, will be spoken of as merely a symptom not a distinct disease.

Neuralgia, or nerve pain in a part may be caused by debility, by cold, or by malaria, or it may accompany pregnancy. Finally, lesions of nerves not necessarily painful may give rise to neuralgia in consequence of disorder of the general health—thus cases are met with frequently in which the diseased pulps of carious teeth, previously the seat of little or no pain, give rise to severe neuralgia when the patient has become lowered by disease or by exhaustion.

Neuralgia is a disease of adult life and old age, it is more frequent in women than in men, and perhaps mostly affects neuropathic subjects.

Neuralgic pain is usually of a plunging, lancinating or burning character, following the course of the nerve branches. It occurs in paroxysms which are often regularly periodic, the pain commencing at a particular hour of the day, lasting a certain period, and then disappearing completely for a time.

The pathology of neuralgia has not yet been clearly made out; and when a local or distant exciting cause consisting of an inflammatory or other recognisable morbid condition, involving nerve centres or nerves is not discoverable, the etiology of the disease is often extremely obscure. When we remember the physiological fact mentioned at the opening of this section, and consider that the fifth nerve which supplies the teeth is distributed also to nearly the whole of the head and face, it is at least, not difficult to understand that diseases of the teeth may act as frequent exciting causes of facial neuralgia. And since, as is pretty generally acknowledged, there are no symptoms which serve to distinguish neuralgia due either to remote or to constitutional causes, from that set up entirely by local disease, it is impossible to overrate the importance of searching for lesions of the nerve in all cases in which doubt exists.

Any of the pathological conditions of the teeth which have been described in preceding sections are capable of giving rise to neuralgic pain, but among them all chronic inflammation of the pulp is the most frequent cause. In every case of facial neuralgia a careful examination of the teeth should be made. Diagnosis even of inflammation of the pulp is by no means always quite simple, and it is not sufficient to take the patient's

assurance that his teeth are not decayed, or that he does not suffer from toothache. Patients are often unconscious of the presence of disease, and teeth which do not ache are frequently the excitants of distant neuralgic pain. Patients—for example—very often suffer for months or years from "earache," demonstrably due to impacted or diseased lower molars or wisdom teeth—teeth which either do not ache, or do not attract attention. In every case of pain in the ear, where no other cause is readily discoverable, the teeth should be examined. This point has been lately emphasised by Dr. Head.* He narrates a case in which exposure of the pulp in a molar tooth in the lower jaw had caused such intense pain as to mislead both patient and physician into thinking that the ear was diseased. In another case a perfectly healthy *membrana tympani* was incised for the relief of pain that entirely ceased with the destruction of an exposed nerve in the second lower molar; in another case exploration of the mastoid was suggested for relief of pain proved afterwards to be due to a carious lower molar.

Isolated nodules of secondary dentine which are not infrequently found in the pulps of externally healthy teeth, seem often associated with neuralgia, though their existence can never be demonstrated till the tooth has been extracted and split open. The pulps of such teeth are probably sometimes the seat of irritation or extremely mild inflammation, due to some obscure cause.

When complaint is made of both toothache and neuralgia, local conditions cannot of course escape attention.

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*Article, "Neuralgia" in "A System of Medicine." Edited by Clifford Allbut, 1899.

In examining a case of neuralgia it is necessary that every tooth be examined separately. Cavities hidden in the interstices or below the gum must be sought for. Fine curved dental probes carefully passed over the neck and hidden surfaces of a tooth will often discover a cavity, perhaps having only a small external aperture, but passing deeply towards the pulp. A small opening in the enamel will often lead into a cavity in which the dentine, if not destroyed, is softened and disorganised as far as the surface of the pulp; and this is in consequence inflamed. Cavities hidden in interstices and on approximal surfaces invisible to ordinary examination, must be sought for. The difficulty of detecting decay affecting surfaces of teeth in close apposition is increased where jaws are crowded. The crown of a sound tooth is often tightly wedged against a carious neighbour, completely preventing a view of the cavity and even rendering approach impossible without the cutting of a way. Some of the worst examples of this kind associated with neuralgia are found in connection with the lower wisdom tooth. The signs of necrosis, exostosis, inflammation and thickening of the dental periosteum must not be overlooked. The teeth may be percussed one by one; a slight smart tap or two with a steel instrument directed upon the masticating surface will often reveal an extra sensibility in one or other of the set, which, on further scrutiny, may be found the seat of disease. A stream of cold water from a small syringe is also a useful test for extra sensibility. This test, as also probing, when the probe touches the pulp, will not uncommonly excite the neuralgic pain; and this although the pain is regrettable, is often satisfactory in establishing a diagnosis.

Filled teeth, and especially those with large metallic

stoppings which appear nearly to approach the pulp, must be carefully scrutinised; for it often happens that the pulps of such teeth pass into a state of irritation, congestion, or inflammation. Where doubt exists, especially where hyperæsthesia is present, stoppings must be removed, and further examination carried out. The mass of pulp in a molar will sometimes be found dead, whilst the nerve in one or other root canal retains its vitality and is inflamed. Where teeth in various conditions of decay are present, it will occasionally be found that the source of pain lies in those not most broken down.

In teeth in the later stages of decay the pulp will mostly have been to a greater or less degree devitalised or destroyed by inflammatory changes; whereas in those in which caries has more recently penetrated to the centre, the pulp will be found entire and with undiminished sensibility.

Artificial crowns must be closely scrutinised; and where "bridge work" is fixed in the mouth, diseased roots concealed beneath must be sought for.

Decayed and broken-down wisdom teeth (common causes of neuralgia and especially of pain in the ear) are often, owing to their position, difficult to discover. They are in many instances placed at the extremity of the alveolar ridge, and in the upper jaw are invisible except with a mouth mirror; whilst in the lower jaw they are commonly hidden by folds of the cheek or by overhanging gum. Decaying in many instances before they are completely erupted, these teeth after the destruction of their crowns by caries are occasionally quite invisible, and their presence in the sockets can be ascertained only by passing a probe through the small fistulous tract in the gum which covers them. A condition similar to this may also exist in the case of any

other tooth, and buried roots, especially when the seat of exostosis, are the excitants of neuralgia in numerous instances. Impacted lower wisdom teeth, which may be free from decay, are sometimes the cause of intense neuralgia. The neuralgia in such a case is doubtless due to direct pressure of the tooth upon the nerve trunk, which runs in close proximity to the root.

In one case of severe neuralgia in which Mr. Henry Sewill extracted an impacted lower wisdom tooth, it was found that the trunk of the inferior dental nerve had traversed a foramen in one root and a deep groove in the other. Complete anæsthesia of the parts supplied by the nerve immediately followed the operation, but

FIG. 240.

recovery of sensation slowly returned in the course of months. Many cases have been recorded of a similar kind, although in none has the trunk of the nerve actually appeared in such close relation to a tooth.

Fig. 240 is from a drawing of the tooth which is preserved in the museum of the Odontological Society. The bristle shows the course taken by the nerve.

The age of patients is often a guide to diagnosis. Facial neuralgia in the young, in the vast majority of cases, is due to dental disease or other similar local irritation. Neuralgia of other origin, "epileptiform" neuralgia and inveterate "tic" are extremely rare before middle age.

It has already been explained in a previous chapter that in most cases, as the teeth become worn down in advancing age, the exposed dentine becomes hardened, polished and insensitive; but it often remains more or less sensitive throughout or develops extra-sensibility at some period; and the teeth may pass into a condition of general hyperæsthesia, in which sudden slight pressure, as in biting on the masticating surface, will inflict a severe pang, or exposure to hot or cold fluids, bring on an attack of pain. Teeth so affected are common excitants of neuralgia. On examination after extraction the pulps are usually found extensively calcified, the new tissue being scattered in isolated nodules throughout, and the remaining pulp showing traces of extremely slight inflammation.*

Badly-fitting artificial teeth are capable of causing neuralgia. This they may do in several ways: by pressure upon the gums; by causing erosion of tooth surfaces; and by giving rise to strain and tension upon remaining teeth.

Other surgical diseases, besides those of the teeth, may involve branches of the fifth nerve, and therefore originate neuralgia, and in every case of doubtful diagnosis it is necessary to examine, as far as possible, the whole course of the nerve. The nerve, or its branches, may be compressed by a tumour or aneurism, or be affected by inflammation, exostosis, or necrosis of the bony canals through which they pass.

Mr. Bland Sutton (Clinical Society, 1889) has recorded a case in which a woman was supposed to be suffering from neuralgia due to bad teeth. Subsequently a slight displacement of the eyeball was detected, and a critical examination of the patient led to the diagnosis of a

* The treatment of this condition is given in a previous section, page 457, under the heading "Abrasion."

tumour entangling the infra-orbital nerve. The skin supplied by the palpebral, nasal, and labial branches of this nerve was anæsthetic, yet she suffered agonising pain referred to that region. The anterior wall of the maxilla was removed by operation, and the antrum found occupied by a tumour. The whole of the maxilla was then removed, and Meckel's ganglion exposed and destroyed by the cautery. An admirable recovery re-

FIG. 241.

sulted. On subsequent dissection the tumour was found to be a myxoma springing from the infra-orbital nerve, and invading the orbit and antrum.

Fig. 241 is an accurate drawing of the tumour.

This case deserves notice for more than one reason. In the first place, in cases of intense neuralgia in the neighbourhood where every other sufficient cause is absent, it shows the necessity for careful examination of the antrum. A slowly growing tumour of the kind

might keep up constant intense neuralgia for years before revealing itself by objective symptoms. In the second place, the case shows the desirableness of putting beyond doubt the character of a growth before performing such a serious operation as ablation of the whole maxilla. Had a correct diagnosis been made at an earlier stage in this instance, it can hardly be doubted that enucleation of the morbid growth would have sufficed.

Inflammation of the mucous membrane of the antrum may include the superior dental nerves. Empyema of the antrum, particularly when the cavity becomes distended by accumulation of pus, is mostly attended by severe facial neuralgia and toothache. Disease in the orbit may affect the first division of the fifth. One case is reported by Niemeyer in which a foreign body was imbedded in a branch of the nerve. Syphilitic nodes of the head are accompanied by pain, with nightly exacerbations of a character similar to neuralgia.

It has been suggested and with considerable show of reason, but without absolute proof, that extraction of teeth may act as a cause of neuralgia, particularly in patients with a predisposition to the disease. The operation, undoubtedly, gives rise to stretching and laceration of the delicate nerve-filaments which enter the tooth ; and it is supposed either that changes may afterwards take place in the lacerated nerve-ends, such as are sometimes found in the nerves of amputated stumps the seat of neuralgia, or that the injury to the peripheral branches may in some way permanently influence the main trunk. If this be true, it is easy to understand that in facial neuralgia the removal of teeth, not the origin of the pain, may sometimes aggravate the evil for which relief is sought.

Certain cases of neuralgia of a nature hitherto undescribed have been observed by Mr. Sefton Sewill.* These were cases of severe pain in connection with loss of teeth. The prominent feature was the pertinacity of the pain, and its aggravation by efforts to open the mouth or to perform the function of mastication, either being sufficient to produce a violent paroxysm. The two cases first seen were in persons almost entirely edentulous; but subsequent observations have shown that the loss of back teeth—molars and bicuspids—even in one jaw alone, is primarily responsible for the condition.

The pain was localised to the auriculo-temporal nerve and its branches, the maximum of intensity being over the molar process, or in the vicinity of the temporo-maxillary articulation. In one case the patient was unable to separate the jaws without causing immediate onset of the pain. The pain radiated over the whole of the right side of the face and temple, and was accompanied by spasmodic trismus of the masticatory muscles, injection of the conjunctiva of the right eye and lachrymation. It was found, incidentally, that after forcible stretching of the jaws the patient was better, and that after artificial teeth had been inserted the pain entirely disappeared and did not return.

The succeeding cases differed materially in no way, but in several of them the patient was not, as in the first case, entirely edentulous. In the case of a man who had been suffering for fourteen years from neuralgia, the pain ceased within twenty-four hours of the insertion of an artificial denture. In another case of long standing, in which teeth in the lower jaw only were lost, and which was cured by the insertion of artificial

* Brit. Med. Journal, Jan., 1897.

molars and bicuspids, recurrence of pain could be immediately caused by merely removing the plate.

The cause of this condition appears to be irritation of the articular branches of the fifth nerve (derived from the auriculo-temporal nerve), due to the alteration of normal arrangement of the structures forming the joint, owing to loss of teeth and degenerative changes in the muscles. These cases bear a resemblance in their intensity and resistance to ordinary methods of treatment to true neuralgia or tic-douloureux, for the relief of which serious surgical interference, even the removal of the Gasserian ganglion is performed; and they suggest a point in diagnosis which deserves to be remembered.

Although in cases of obstinate neuralgia there can be no doubt of the propriety of removing such diseased teeth as cannot be brought by treatment into a healthy state, it must be borne in mind that all decayed teeth need not be condemned to extraction. Neuralgia may be often cured by destroying inflamed pulps, and may be guarded against by filling cavities, and protecting the sensitive structures of the teeth from irritation. In these operations care should be taken to avoid increasing the susceptibility of the teeth to changes of temperature. For this purpose any of the cements not containing chloride of zinc answer admirably, and in cases in which the pulp is protected only by a thin covering of dentine, a layer of cement should be applied beneath the filling to the bottom of the cavity in the manner described in a former page.

The discovery and removal of the exciting cause must be the first care in dealing with neuralgia, but the treatment of the predisposing causes must not be overlooked. It has been already pointed out that the state of the general health often determines whether we have to attack slight local pain or severe neuralgia. Conversely,

with improvement of the general health the pain frequently disappears, although the exciting cause may remain.

Epileptiform neuralgia or tic-douloureux in its earliest stages closely resembles ordinary neuralgic pain due to a slight local cause; and it is in these cases the dentist will often be urged by the patient to extract teeth, which, whilst really the seat of pain, are perhaps perfectly free from caries or any sign of disease. The characteristic of this form of neuralgia is its more or less rapid progress in spite of all treatment. First appearing perhaps as mild neuralgic toothache, it gradually involves more and more nerve branches belonging to one division of the fifth, and at length spreads to all three divisions. At the same time the pain becomes more frequent; its intensity increases, and the duration of the attacks lengthens. During a paroxysm, the muscles of the face are often convulsed, profuse lachrymation and local sweating frequently occur, and the aspect of anguish presented by the patient indicates the terrible severity of his suffering. The general health soon begins to suffer, since sleep becomes impossible without hypnotics or anodynes; whilst if these drugs are administered in large doses they help to break down the nervous system.

In cases like these, in which the cause of neuralgia, whether local, central, or constitutional, cannot be discovered, an attempt may be made to destroy the excitability of the painful nerves. For this purpose electricity in various forms is employed. Cold, which diminishes for a time the excitability of the nerves, may be applied to the skin by means of ice or evaporating lotions; and ointments of aconite or veratria, or lotions of belladonna and chloroform, produce similar effects.

The division of the nerve at some point between the seat of pain and the brain, or (as section would be speedily followed by re-union) the cutting out of a portion of the nerve, is a procedure which theoretically seems likely to prove efficacious by preventing communication between the affected nerve and the brain. The operation is sometimes attempted, especially when the pain appears to have its seat in the ramifications of the mental nerve. It is, however, seldom followed by permanently good results, and for three reasons: first, because it is difficult to pick out the nerve which is really the seat of pain, secondly, because it is difficult to get at and divide a part of the nerve between the brain and seat of the disease which excites the neuralgia, and lastly, because the divided parts very soon re-unite. To overcome the last of these objections it has now become usual to cut out so great a length of nerve as shall effectually prevent re-union; and this procedure has in many cases proved successful. The point where division would succeed, is in many instances, doubtless, so deeply placed that, even if discoverable, to reach it would be impossible. Stretching the nerve is considered by some most efficacious, but the second or third divisions of the fifth are very inaccessible for this operation.

No other really curative treatment being available, and life becoming intolerable to the patient, in many cases of epileptiform neuralgia, the operation for the removal of the Gasserian ganglion at the base of the skull has in late years been introduced. This operation is now a regular procedure in surgery; and cases so treated have been cured and have remained free from pain for years.

With regard to diagnosis and treatment, the dental

surgeon's part in dealing with neuralgia is well defined. It is impossible to formulate rational treatment without knowledge of etiology; and no physician will treat a case of neuralgia of the face without satisfying himself that the cause does not lie, partly or entirely, in dental disease. It is the dental surgeon's duty to ascertain whether disease of teeth, sufficient to account for the pain, exists. He often finds that a case has been treated medically for months, where the pain has its sole origin in inflammation within and around teeth—a fact of which the patient (as already pointed out) is often unaware.

Whilst it is, no doubt, desirable in cases of obstinate neuralgia that teeth the seat of chronic incurable conditions should be extracted, the dentist, on the other hand, must be on his guard against sacrifice of sound teeth the seat of purely neuralgic pain.

In treatment the dental surgeon's share consists in removing hopelessly decayed teeth and bringing others into a healthy state. This is often the sole treatment called for in facial neuralgia. When further measures, either surgical or medical, are required, the case passes beyond the practice of dentistry.

Nervous Disorders.—Irritation of peripheral nerves, besides exciting distant pain, may give rise to reflex irritation, or to functional disturbance of the brain or other great nerve centres, resulting in various phases of morbid action; and although dental diseases very rarely excite nervous affections of a nature more grave than neuralgia, yet there is evidence that neuroses of the severer kind do occasionally result from irritation of the dental nerves. Reflex irritation may be transmitted both to motor and sympathetic fibres. It was, for example, mentioned in the previous section that severe neuralgia of the face is sometimes accompanied by

convulsion of the facial muscles, together with profuse flow of tears, saliva, and mucus, and perspiration on the skin at the seat of pain.

Among observers belonging to the early or middle period of the nineteenth century, before neuro-pathology had advanced to its present position, theories of causation were very often set forth which would not be accepted at the present day. Thus Esquirol and Ashburner relate cases in which mania and delusions accompanied difficult eruption of wisdom teeth, and were, apparently, cured by incision into the gum over these teeth; and many not less questionable cases in which simple dental disease is set down as cause of grave neuroses are related by the older writers.

Epilepsy.—Sir J. Tomes (writing about the year 1859) reported two cases of epilepsy believed to be consequent upon diseased teeth, the seat of exostosis.

In view of the fact that there has been described a variety of epilepsy believed to be due to irritation of peripheral nerves, probably no authority on this subject would deny the bare possibility of diseased teeth acting as the effectual or efficient cause of that malady. If such cases occur they must be extremely rare; very few modern authorities discuss such a cause; and cases of the kind are almost undiscoverable in the writings of leading neuro-pathologists of the present day. It is possible to gather records of a few cases from the works of older writers—cases too briefly described, as a rule, to be of much scientific importance—and perhaps half a dozen of such cases having been passed on from writer to writer during the past fifty years, have done duty as illustrations in the older works on dental surgery. Whilst few neuro-pathologists having valid claim to authority, will set down dental disease of any kind among the actual prime causes of the epileptic state,

none will deny the evil effect which diseased teeth—and especially inflammation of the pulp—may have upon subjects of this malady. Visceral and peripheral irritation are common causes of increase in the number and severity of fits. Constipation and the presence of intestinal worms afford common examples of this; and cases are not rare where a small wound of the extremities—such as a puncture of the foot containing a small foreign body—has under repeated irritation on each occasion determined the immediate onset of a convulsion. A case was recorded some years ago in the *Transactions of the Odontological Society* by Mr. Sewill, in which accidental plunge of an excavator into an inflamed dental pulp, brought on at once a typical epileptic fit in a youth in whom no such seizure had been previously observed. Enquiry, however, elicited the fact that the patient had been affected for some time by premonitory symptoms in the form of *petit mal.*

The etiology and treatment of epilepsy, and of other allied and similar diseases of the nervous system are subjects far outside the range of dental surgery. These cases do not come as such under the notice of the dental sugeon, and it is not within his province to consider them. Cases will be sent to him with the statement that the patient being the subject of such and such a malady, it is desired that every source of dental irritation should be removed; and occasionally it may be the duty of the dental practitioner to point out the importance of attention to the teeth in particular cases. There the dental surgeon's duty begins and ends.

Secondary Affections of the Eye.—Cases of ophthalmic disease due to diseased teeth have been

occasionally recorded, and these have been accounted for on the supposition that irritation of dental branches of the fifth nerve may be transmitted through the ciliary system to the retina, producing hyperæmia and inflammation.

Neuralgia in or about the orbit is very commonly due to diseased teeth of the upper jaw. The pain may be so severe as to simulate serious inflammation or other morbid process within the eyeball; and, as in the cases of pain in the ear due to diseased teeth (mentioned in the section on neuralgia) care must be taken lest a disastrous mistake in diagnosis be made.

In a paper read before the Odontological Society in June, 1883,* Mr. Henry Power gave it as his opinion that in all cases of threatening glaucoma, especially when this is associated with ciliary neurosis and obscure pain in the temples and maxillary orbital regions: in all cases of mydriasis and probably of myosis, originating without apparent causes: in all cases of sudden paralysis of either of the orbital muscles, or of loss of sensation in the absence of cerebral symptoms: in all cases of phlyctenular disease of the conjunctiva: in all cases of ulcers of the cornea resisting ordinary treatment: in all cases of sudden failure of the accommodation, especially in young children: and finally in all cases of exophthalmos, the condition of the teeth should at least be examined, and if faulty conditions present themselves, these should be at once rectified, and then one at least of the possible causes of each of these diseases will be removed.

At the same meeting the following case (reported in the same volume of *Transactions*) was related by Mr. Sewill.

The patient was a middle-aged lady, unmarried, and of nervous temperament, who had suffered all her life

* Trans. Odont. Soc., 1883.

from bad teeth, and at times from neuralgia. About the year 1880 her eyes began to be uncomfortable; she was troubled with pricking and smarting in them. In January, 1882, contraction of the muscles of the right side of the face came on, and she began to suffer from neuralgic pain on that side. In July of that year drooping of the right eyelid came on suddenly, and she discovered that she had lost the sight of her right eye. She then consulted Sir W. Hoffmeister, of Cowes, who, finding that her teeth were in a very bad state, and suspecting that they might be the cause of her ailments, strongly advised her to have them attended to, but the patient refused.

In July, 1883, she consulted Dr. Ferrier, who found her suffering from contraction of the muscles of the right side of her face, with local hyperæsthesia; from neuralgia of that side of the face, and from inability to open the right eye, though she could do this with an effort. The closure of the eye was found to be due to spasm of the orbicularis muscle. The lens of the right eye was almost opaque. Finding that her teeth were in a very neglected state, and believing that this was the cause of the neuralgia and probably also of the cataract, Dr. Ferrier insisted that she should consult a dentist.

It was found that in the upper jaw the right canine was broken down level with the gum, and four necrosed carious front teeth and some molar roots covered with tartar, were present. There was fixed to these teeth and stumps a vulcanite plate, also encrusted with tartar, which had not been removed from the mouth for several years. There was much inflammatory swelling and thickening extending from the roots towards the orbit. The gums were inflamed and tender, all the teeth having evidently been the centres of long-standing inflammation.

In the lower jaw there were ten teeth, also coated with an enormous mass of tartar.

The upper teeth were extracted, the tartar from the lower teeth removed, and the mouth brought into a healthy state. The patient was then supplied with an upper set of artificial teeth. The result of this treatment was that the spasm of the facial muscles slowly subsided and did not recur, she was able to open the eye, and she lost the neuralgia. Her general health was also greatly improved, but there was, of course, no improvement in the state of the cataractous lens.

It would probably be considered in this case that, however strong the presumption, it could not be reckoned as proved that the organic injury to the eyeball was caused through the influence of the nervous system by the dental disease; but there would be less difficulty in ascribing the muscular spasms to such a cause. Many cases of spasm of the orbicular muscle (blepharospasm) and other muscular spasms of the eye probably due to diseased teeth are recorded. Cases are very rare in which the connection between ophthalmic disease and morbid conditions of the teeth seems more fully established than in this instance, and few authorities ascribe as much importance to dental disease as Mr. Power. But, in face of the opinion of an authority like Mr. Power, medical practitioners are not likely to overlook this cause when the etiology of any case remains in doubt.

Herpes of the Face.—The association of nerve irritation with herpes is very common at various surfaces of the body, but has not been frequently observed on the face. The occurrence occasionally of an eruption on the skin in cases of empyema of the antrum was referred to on an earlier page; and the effect, if due to that cause, could of course be brought about only through

the nervous system. Cases of herpes of the face, apparently due to irritation of the mouth and teeth, have been observed by Mr. Malcolm Morris and Mr. England. The following in which the cause seemed indubitable may be cited. A young married lady wearing a complete upper and partial lower set of artificial teeth, suffered from herpetic eruption on the left lower cheek, over the bone of the lower jaw extending from the angle of the lip to the ear. The eruption broke out at intervals, during many months, lasted on each occasion several weeks, and then disappeared. The attacks seemed unaffected by treatment. On consulting Mr. Malcolm Morris, she was advised to discard wearing the lower set, which seemed a cause of irritation. She obeyed; and the eruption disappeared and did not return during an interval of over a year. The patient then applied to try if a plate could be fitted. Careful examination revealed no tender area. A new lower plate was fitted and the patient was instructed that if it caused pain it was not to be worn. After eight hours without discomfort an eruption began to appear in the same position as on previous occasions. The plate was immediately removed and the eruption disappeared within forty-eight hours. Another examination revealed no tender areas. It was, however, thought best to relieve the gums of the affected side of all pressure and the bite of the teeth was therefore arranged to ensure this. The patient was then able to wear the plate with comfort, and the herpes did not return during the eighteen months the patient remained under observation.

A young unmarried lady suffered from a periodical eruption of herpes on the skin over the lower jaw in the vicinity of the first bicuspids and molar. The eruption would appear, last for a fortnight, and gradually disappear; and after an interval of two or three months

would re-appear. It seemed to be unaffected by treatment.

On consulting Mr. Malcolm Morris, the patient was advised that the eruption was probably due to dental irritation.

On examination it was found that the first left lower bicuspid and first left molar were hopelessly decayed. The second left lower bicuspid contained a large metal filling and the pulp appeared to be dead. On removal of the filling it was found that it had been placed immediately over an exposed pulp. The nerve was found to be alive in the lower third of the tooth. An attempt was made to detroy it, but the attempt was followed by an increase of the eruption and the tooth was therefore removed. The remains of the other two teeth had been previously extracted. The eruption then disappeared and did not recur.

It is remarkable that throughout this case the patient suffered no toothache.

EXTRACTION OF TEETH.

THE indications for extraction have been given in the various chapters on irregularity and diseases of the teeth. A vast number of decayed teeth which might be saved are, however, too commonly extracted for the relief of easily curable transient acute pain. Acute inflammation of the pulp is by far the commonest source of pain for which extraction is demanded by patients. It is one of the conditions of dental disease, the pressing symptoms of which are most amenable to treatment, and this does not inflict so much suffering as extraction, nor does it demand greater skill on the part of the operator. The value of a particular tooth in different cases varies very much. For example, to extract an incisor or canine for the relief of pain due to inflammation of the pulp, or any inflammatory condition certain to yield to suitable measures, must, at the present day, be reckoned barbarous; whereas under the same circumstances extraction of a mal-placed useless wisdom tooth might be highly judicious and appropriate practice. Similar remarks apply to truncated teeth and roots. A tooth with a delicate crown which has been rapidly destroyed by caries will possess in numerous instances a massive root which may be preserved to hold a stopping or to support an artificial crown for many years. In most instances, but especially for the poor, it is better the patient should retain painless roots or decayed teeth, although unfilled, than go with edentulous jaws.

Before commencing the operation of extraction a careful examination should be made. For the reasons given in the chapter on toothache and neuralgia, it is first necessary, when the operation is for relief of suffering, to make sure that the tooth indicated by the patient is really the cause of pain.

An operator who indiscriminately extracts teeth which the patient points to as the source of suffering must, in a large proportion of cases, draw a wrong tooth, and almost as often, sacrifice a perfectly sound one.

All doubt having been done away with as to the tooth to be drawn, the tooth may be minutely examined with mirror and probe. All instruments likely to be needed in the case should next be placed within reach. Delay in laying hands on these may prolong the patient's suffering. The effect of an anæsthetic so transient as nitrous oxide—that mostly used in dentistry—may pass off whilst time is lost in searching for instruments after the operation is commenced. In the majority of cases the teeth to be extracted are badly decayed. Deliberate scrutiny may show whether the tooth is likely to yield to a first attempt, or whether the roots will need extraction separately. Seeing the uncertainty of the operation even with a sound tooth, inasmuch as it is never possible to ascertain positively beforehand whether roots may not be abnormal in size or shape, it is better in every case to have at hand root forceps and elevators suitable to deal with contingencies which seem likely to present themselves. It may be noted generally, first, that teeth of the upper jaw as a rule present less difficulties than those of the lower, the bone, particularly in the deeper parts of the alveoli, being comparatively less dense, compact and unyielding in the upper than in the lower jaw; and secondly, that teeth the seat of acute or chronic periosteal inflammation and suppuration being already

loosened by the processes of disease, are proportionally more easily grasped and extracted than teeth not so affected.

The operation of extraction demands considerable readiness of resource. The contingencies which attend it occur suddenly, often without warning, and they mostly need to be recognised and dealt with on the instant. To become a good extractor needs, therefore, thorough instruction and ample practice. Practice should be systematically carried out on the dead subject before the student is allowed to operate on the living. It is only in this way that he can so educate his sense of touch as to rapidly recognise the varying conditions which suddenly present themselves whilst wielding instruments during an operation.

The instruments employed almost exclusively are forceps. These are made with blades of various patterns adapted to fit the different classes of teeth, and to grasp without crushing them. Their edges are sharp that they may be readily insinuated between the edge of the gum and the neck of the tooth, and forced towards the socket.

No dental operation depends for success so much as extraction on the design and quality of instruments. With badly-made, blunt-edged forceps it is impossible to obtain a sufficiently firm and deep grip, and difficult to avoid crushing and splintering the tooth. Every pair of forceps ought in the making to be separately fitted to a tooth of average size. The steel should be of the best quality and temper, so that the blades may possess the requisite strength whilst not being thick and clumsy. The edges should be fine and should be kept sharp, so that they may be easily insinuated between the root and the alveolar wall. They are very apt to be turned by forcible contact with the alveolar margin, and if this

happens they should be carefully set before they are again used. If a cutler is not to be had, this can be done with a file, followed by a small water-of-Ayr stone hone, or better, with stone discs and the dental engine. A well-made forceps applied to a tooth ought in different stages of the operation to fit as accurately as the instruments represented in figs. 242, 243, 246, 249, and 253. The blades of a badly-designed forceps will often be found to exert great crushing force at a single point only on the sides of the tooth instead of distributing the pressure evenly throughout. The necessity of keeping forceps like all other surgical instruments in an aseptic condition hardly calls for more than mention.*

The patient during extraction may be placed on a couch with the shoulders raised upon pillows and the head thrown back in a good light, the surgeon standing in some cases on the patient's right side, in some behind the head. This arrangement will serve for any tooth, and is particularly convenient for performance of prolonged operations with anæsthetics. For extraction of teeth of the lower jaw (of course where an anæsthetic is not used) the patient may be seated on a low chair or stool, with the head either firmly grasped between the operator's knees or held by an assistant, who at the same time may with one hand support and fix the jaw. If in a dentist's chair, the patient, when an upper tooth is to be drawn, should be thrown back at a moderate angle, with the head about as high as the surgeon's breast; for a tooth of the under jaw the chair

* Two cases of death following tooth extraction have been reported in the public press during the months that this edition has been in preparation. The tooth in each case had been drawn by an unqualified practitioner. An inquest in each case was held; and the medical evidence based upon *post-mortem* examination proved the deaths to be due to septicæmia, the result of infection of the alveolar wounds. In one case comment was made on the rough character of the forceps which had been used.

should be almost upright and with the patient's head about on a level with the surgeon's hip.

An expert operator having a dentist's chair and usual appliances will in ordinary circumstances rarely need assistance in extracting a tooth. An assistant knowing what to do and how to do it is, however, always useful, and where rapidity is called for—as, for example, when nitrous oxide is used—may be very valuable. Standing behind the patient when upper teeth are to be drawn, he may firmly grasp and fix the patient's head and turn it when needful towards the surgeon. When lower teeth are to be removed the assistant may stand on the patient's left and with one hand steady the head, whilst with the other he takes a firm grip of the chin or jaw and presses it upwards and backwards so as to oppose the force exerted by the operator to enable him with certainty to thrust the instrument home and to set both hands free for the direct work of the moment.

The operation of extraction consists of two distinct actions, first the seizure of the tooth, and second the loosening of its connections, and its withdrawal from the socket. It is upon the careful performance of the first step of the operation that success in the main depends.

The seizure of the teeth of each class is effected in the same manner. The forceps is lightly applied to the tooth, and the edges insinuated within the free edge of the gum. It is then pushed along the root, enough force being steadily exercised to drive the blades well round the root down to and within the edge of the alveolus. The grasp is then tightened, but not to such an extent as to crush the tooth, and the next step of the operation is proceeded with. As soon as the tooth is felt to yield the forceps may be pressed still deeper, so as to embrace the root within the socket, to obtain more

power and to avoid breaking off the crown. The calibre of all roots decreases towards the apices, so that a space which becomes greater with every outward movement is left between the root and the alveolar wall as soon as the tooth is started. With each movement of the tooth the forceps can, when necessary, be pressed further until so deep a grip is obtained that fracture of the tooth is rendered almost impossible. It is the exception for any serious difficulty to present itself in the removal of a tooth effectually grasped in the way described, and the utmost care must therefore be taken to ensure this. The amount of resistance in any case cannot be discovered until the operation has advanced. A tooth which is loose to the touch may yet be held in place by wide-spreading or enlarged or exostosed roots; and teeth, especially molars, with small crowns often possess roots of disproportionate size. To carry out deliberately and fully the first stage of the operation is not to inflict unnecessary pain. Should the tooth prove of weak attachment very little more will be needed to extract it, whilst if it is firmly fixed the deep secure grip of the forceps will shorten and make certain the final stage.

It is not necessary, as it was with the obsolete key, to separate the gum from the neck of the tooth by means of the lancet before applying the forceps. The connection of these parts is slight, and moreover, they are divided with greater readiness and certainty by the sharp cutting edges of well-made forceps than with a scalpel. The mode of holding forceps and applying them to teeth is shown in figs. 242, 243, 246, 249 and 253.

In the second stage of the operation the method of applying force is modified with each class of tooth, since the roots in each class vary in number, position, form, and size, and the investing bone offers less

resistance in some directions than in others. This stage of the operation, although distinct from the first, is really continuous with it, the whole procedure being effected with an even unbroken series of movements.

FIG. 242.

The operation may be performed rapidly by a practised hand, but it must be remembered that an attempt to wrench a tooth from its socket by force, either wrongly directed or recklessly applied, will, in most cases, result in fracture of the tooth, and may also inflict severe injury upon the jaw and surrounding parts.

The rapidity with which a skilful hand is able safely to perform this operation is remarkable. Two or three molars are often extracted during the brief anæsthesia—to be counted in seconds—of nitrous oxide gas. A few

FIG. 243.

apparently simple movements of the hand and wrist and each large tooth is laid upon the table; and yet careful examination will disclose no injury—not so much as a bruising of the gum—to the structures around. Every one of the rapid movements of such a practised hand

will have been guided and directed by an educated tactile sense; and every movement will have been prolonged and modified in accordance with the resistance felt and appreciated. For the unpractised operator the only safety lies in less speed and more deliberation. At most a few seconds more of time need only be expended, and

FIG. 244. FIG. 245.

perhaps one instead of two teeth be drawn under a rapidly transient anæsthesia. If an anæsthetic be not used it may probably be considered better to prolong the suffering of the patient for a few seconds and bring about a successful result, rather than to hurry the operation, badly break the tooth, and inflict greater pain in efforts to extract the fragments afterwards.

The articulation of a tooth with its socket has been compared very appropriately to the impaction of a nail in wood, and if the student considers and recognises the method necessary to draw a nail intact from its position *without injury to the surrounding wood,* he will perceive

FIG. 246.

the principles upon which tooth extraction must also be carried out. The necessity of a deep grip has been already dwelt upon. It will be next evident that loosening movements must not be carried to excess in one direction. Too far forcing outward or inward may, instead of bending, fracture alveolar walls, or snap

instead of loosening a twisted or curved root. In nearly every case forcible pulling besides loosening movements are needed to finally detach a tooth.

The forceps for the extraction of upper incisors is shown in fig. 242. These teeth have conical roots, and their extraction is accomplished by rotating them to the slight degree necessary to loosen them, and pulling them downwards and a little forwards. Upper canines require a stronger but similar instrument, and they are removed by the same method. The roots of incisors and canines are often laterally flattened and besides curved, oftenest backwards. It is only when they are regularly conical and straight that they readily yield to a twisting movement, and it is mostly necessary besides to force them a little forward towards the weakest portion of their socket.

The roots of none of the front teeth, even when most normal in shape, are perfectly conical and it must not be understood that they can be turned in their sockets to more than a slight degree; nor is this necessary to produce the loosening needed in extraction.

The forceps for upper bicuspids is shown in fig. 243. It resembles that used for the incisors and canines, but has narrower blades, and handles bent to clear the lower teeth. The upper bicuspids having roots flattened laterally cannot be rotated. They are loosened by forcing them steadily outwards. They are then moved to and fro from within outwards, and pulled downwards.

The movement of teeth outwards must not be carried far lest the wall of the alveolus be fractured. This movement, and indeed all the movements of extraction in every circumstance, should be made by steady pressure, not with a jerk or sudden force, or fracture through the thin alveolar wall, or perhaps detachment of a portion will be likely. The to-and-fro movements

should be guided by the same considerations; and it is during these movements that the forceps should be simultaneously forced along the root into the space afforded by the exit of the tooth from the alveolus.

Two forceps are required for the upper molars, one adapted to the teeth of the right side, one to those of

FIG. 247.

the left, figs. 244, 245. The outer blade is formed in two curves to contain the external roots, the inner blade is designed to grasp the internal root. A well-fitting forceps applied to an upper molar is shown in fig. 246. The force in extracting these teeth is first applied in the outward direction, for the reason that the external

alveolar plate offers less resistance than the inner, while the direction of the palatine root is such that it is likely to be snapped in an attempt to move the tooth at first inwards. As soon as the tooth yields it is moved from side to side, and pulled downwards.

FIG. 248.

Upper wisdom teeth are extracted in the same way as upper molars. The removal of these teeth, however, rarely requires great force, their roots being often connate and the bone around being cancellated and soft. Ordinary molar forceps may be used for these teeth, but they are more conveniently reached by an instrument—such as shown in fig. 247—specially curved to pass to their position at the extremity of the jaw.

Lower incisor roots are much flattened laterally. These teeth are therefore to be loosened by bending them forwards, and are then completely detached by a to-and-fro movement from within outwards, combined with an upward pull. The forceps for these teeth is depicted in fig. 248.

FIG 249.

Lower canines, having somewhat conical roots, are loosened by a rotatory, combined with a forward movement, and drawn by an upward pull. The forceps closely resemble those used for the incisors.

The lower bicuspids, having roots flattened laterally, are extracted by forcing them outwards until they are

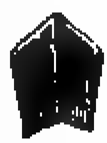
felt to give, then moving them from side to side and at the same time drawing them upwards; the forceps is shown in fig. 248.

FIG. 250.

After applying forceps to lower bicuspids and molars the point of the thumb of the left hand may often be conveniently placed over the joint of the instrument whilst the fingers press the jaw upwards from beneath. In this way the forceps is guided in the desired direction, enough power is obtained to drive it home, and the instrument is prevented from coming into violent contact with the upper jaw at the moment the tooth leaves the socket, whilst at the same time the danger of dislocating the jaw is guarded against. This accident has occurred in some cases.

The lower molars are, as a rule, the only teeth which commonly call for the exercise of great force in their removal; and this occasionally will try the strength of a powerful hand. This is owing to the great size of the roots, which are often spread or twisted within the jaw, and to the dense unyielding character of the bone which envelops them. At the region of the first lower molar the external alveolar wall offers, as a rule, less

FIG. 251. FIG. 252.



resistance than the inner, and these teeth in extraction are best forced in the outward direction. About the second molar the external layer of bone becomes massive and dense, and these teeth yield most easily to force directed inwards. When started, a lower molar is moved to and fro from within outwards and pulled upwards. Should the tooth offer great resistance, a backward and forward tilting movement may be practised by alternately elevating and depressing the handle of the forceps the better to free the roots, which are curved

more or less in the backward direction. The forceps for these teeth is shown in fig. 250, but those in which more powerful leverage is obtained through the blades being at a right angle with the handles are to be preferred by an operator who has not a very powerful wrist. Figs. 251 and 252 show right and left instruments of this pattern commonly called "hawk's-bill." A forceps of this pattern in position is shown in fig. 253. Forceps of a similar design are made also for the other teeth of the lower jaw, and present some advantages over the

FIG. 253.

ordinary pattern. One applied to a bicuspid is shown in fig. 249. Besides their more powerful leverage they allow a better view of the parts during the operation. The modifications in movements which the wielding of these forceps call for are too obvious to need description.

Lower wisdom teeth are extracted by the same method as the second lower molars, than which, however, they require usually less force. A forceps, shown in fig. 250, is provided, with the blades bent at such an angle to the shaft as permits their ready application to these teeth.

These teeth may be, as a rule, most easily extracted with the elevator as described further on.

Extraction of all lower teeth is much facilitated by fixation of the jaw. It should be held and pressed upwards throughout, the more firmly as more force is applied.

Extraction of Roots.—Extraction of single roots which are not broken or decayed within the alveolus

FIG. 254.

presents no greater difficulties than removal of the whole tooth; and, indeed, it is the root and not the crown which is grasped in drawing a tooth, even where the tooth is entire. The extraction of roots is therefore carried out on the principles already described. The forceps is steadily pushed along the root, and a sufficient

grip upon a sound portion obtained before an attempt is made to complete the operation. As the root yields, the thrusting of the instrument deeper may be continued, and by giving the forceps at this time a slightly rotatory movement, the blades are made to penetrate more readily. When the root is extensively decayed or broken within the alveolus the difficulties of root extraction begin. Forceps are used with smaller and more slender blades, that they may be more easily passed into the socket and insinuated between the root and the surrounding bone. Fig. 254 shows a typical root forceps. These instruments are made of different sizes and strength, and with blades and handles curved and bent to reach all classes of roots. Application of the forceps to roots must be made with the utmost deliberation and care. The edges, instead of passing round, are very apt to slip and rest upon the surface of the root in a position in which they cannot be forced deeper.

Properly-made forceps with keen-edged blades placed in accurate position around a root may in many cases be made to penetrate by a trephining movement. The blades of the forceps must be used as a trocar, and by a rotatory action, aided by pressure, must be carried to a depth sufficient to ensure a firm hold. Sometimes a blade may be made to penetrate further along one side than another of a root, and then a judicious exercise of force may so start the root as to allow penetration of the other blade and completion of the operation. The thing to avoid is application of too much force before a grip upon solid root has been gained.

In extracting roots of molars the procedure is guided by the extent of decay. If still firmly united together, roots may be removed by the ordinary forceps, used in the manner already described. Where it appears difficult to obtain a sufficiently deep hold with the

ordinary instrument, forceps specially designed may be employed; but these are rarely necessary if forceps of ordinary design are kept with keen-edged blades. The special instruments are provided with extra long and sharp-pointed blades, which are either

FIG. 255

thrust into the alveolus or forced through the alveolar plate. Fig. 255 shows an instrument of this kind applied to the roots of an upper molar. Fig. 256 shows that used for the same purpose in the lower jaw.

In a large number of instances of broken down upper or lower molars, when the roots are still united although much decayed and in which a deep hold is evidently needed, it is a good plan to use instead of the special instruments just described, a slender-bladed keen-edged stump forceps, with blades as shown in fig. 254, but when necessary with stronger blades running into stouter

FIG. 256.

shafts to resist the great force necessary with large teeth. The shape of the forceps and angle of the blades will be of course modified for different classes of upper and lower teeth. Examples for upper and lower roots are given in figs. 257, 258, and 259. A careful examination having been made, the operation is commenced by thrusting the blades with a trephining

movement to a great depth around a single root; in an upper molar very often two may be so grasped at once. It is frequently possible to drive the forceps steadily in until the root is gripped to near the apex; and it will often be found if a sufficiently deep hold is thus secured not only that the root actually seized, but the whole mass will come away, a mass which might have been crushed into fragments had a heavier instrument

Fig. 257.

Fig. 258.

Fig. 259.

been employed; and should one root only be withdrawn at the first effort, those remaining will commonly be so loosened as to be easily pulled out one by one.

If the body of the crown is so far decayed that the roots are nearly or altogether apart it is well to remove them separately. In some cases the external margins of molar roots having been broken or destroyed by decay the central uniting portion remains solid, and in this condition the mass cannot be grasped with a

forceps. Where the pulp is dead the mass may be divided by a sharp spear-pointed elevator slowly and carefully worked into the centre, or this may be better and more quickly done with a large spear-ended drill and the engine. Dividing forceps with cutting blades to be thrust into the socket are also useful. Patterns

FIG. 260. FIG. 261. FIG. 262

of forceps for this purpose are shown in figs. 260, 261, and 262.

A great variety of forceps have been devised to deal with the difficulties of molar root-extraction, and the

procedures in this operation are varied very much by different practitioners. Many of the skilful rarely employ any but ordinary forceps, using instruments with thoroughly keen edges in extraction of badly decayed teeth in mass and extracting roots with instruments of various strength in the manner just explained. Other operators equally skilful and certain prefer, as a rule, first to divide all root-masses of doubtful coherence and take out each fang separately. Others favour specially designed instruments such as that shown in fig. 263 (Mr. Wood's). This is a modified "hawk's-bill"

FIG. 263.

forceps having an inside cowhorn-shaped beak designed to penetrate deeply between the fangs. With this instrument a badly decayed tooth may often be lifted out of the socket; or if this is not effected in one effort the roots may be divided and loosened so as to be easy of removal. Many other ingenious instruments are illustrated and described in manufacturers' catalogues.

In extracting the roots of teeth of any class, *if they cannot be seized by other means*, there need be no hesitation in including the edge of the alveolus in the forceps, or in cutting through the thin alveolar walls. If this is done with due care the operation may be rapidly performed, whilst no permanent damage is inflicted, seeing that the small portion of bone forming the thin edge of the alveolus which is injured or broken away would be under ordinary circumstances soon removed by absorption after the extraction of the root.

The roots of upper molars being conical, may when separate be detached by a rotatory movement; those of lower, owing to their flattened shape, require a rocking movement from within outwards; but the force must be modified in accordance with the resistance which is encountered in each instance, in consequence of the varied shape and direction of roots.

Other points in the extraction of roots are discussed in the next paragraphs.

Use of the Elevator.—The elevator, an instrument of great use in extraction of roots, consists of a stout handle carrying a steel shaft, which terminates in a narrow blade. The blade is thin, and concave on its inner surface, and has either a spear-shaped or a sharp horizontal edge. Various patterns are used by different operators, but the straight spear-pointed and the rectangular right and left instruments depicted in figs. 264, 265 and 266 suffice for all ordinary purposes. In applying the elevator the blade is thrust into the socket along the root until a solid surface is reached. The handle is then turned, so that the point of the blade impinges upon the root, and by a levering movement prizes it from the socket. In this procedure the fulcrum is necessarily formed, altogether or to a great extent, by the alveolar wall or by the adjoining tooth, and as

the force exercised by the elevator is great, unless care be taken the former may be extensively fractured or the latter dislodged. The elevator should be, therefore, firmly grasped, the fingers reaching close to the blade. The thumb and fingers of the left hand may in some instances serve partly or entirely as a fulcrum, and in every case they should be employed in guiding and supporting the instrument and controlling the force.

The elevator should not be, as a rule, inserted between the external alveolar wall and the root, this part of the bone being too thin to sustain much pressure. It should never be used for the extraction of upper wisdom teeth. The bone around these teeth is so weak as to be readily fractured by force in the direction in which it must be exerted by the elevator.

Some operators acquire uncommon skill in the use of this instrument, but—it may be said generally—the elevator ought not to be used for any operation which can be as well done with forceps. It is, in fact, not commonly called for except in extraction of the lower wisdom teeth and of bicuspid and molar roots of the lower jaw. Lower wisdom teeth may usually be prized from their sockets easily with the elevator, the force which it exerts being exactly in the right direction. A straight spear-bladed instrument, fig. 264, is best. This is thrust along the root at the anterior external margin of the alveolus, and as soon as a sufficient depth is reached on a sound surface of root the tooth can be gradually forced out of its socket by a levering upward and inward movement. When the tooth has been started the elevator can, when necessary, be pressed further along the root. The roots of lower bicuspids, molars, and wisdom teeth, may be removed with either the straight or right-angled elevator—the latter being the better for bicuspid roots and also when the instru-

ment is to be applied to a distal surface. It will be sometimes found either easier or more expedient to attack a root at one side than the other, the choice

FIG 264. FIG. 265. FIG. 266.

being governed by the position and extent of decay and the relations of neighbouring roots and teeth to the condemned root. The elevator is very useful for the removal of loose roots and fragments of roots, such

as necrosed portions of temporary molars, which are so often in neglected mouths found lying attached within the gum around recently-erupted bicuspids. Other uses are found for this instrument in the dislodgment of impacted teeth and roots or partially erupted teeth. It is very often possible where a forceps could not be applied to insinuate the point of an elevator, and by a careful levering movement either entirely to dislodge a tooth or root, or so to loosen it as to render possible its removal by the forceps.

In cases of closure of the jaws due to impacted lower wisdom tooth or periostitis around molars, the elevator is often indispensable. In these cases, even with the aid of powerful lever or screw gags, it is commonly impossible to separate the jaws sufficiently to allow of the application of forceps. With an elevator the tooth may be, however, almost invariably reached, the swelling within the socket allows the blade to penetrate, and the tooth may usually be gradually prized from its position.

Extraction of Crowded Teeth.—Cases of crowded teeth were illustrated in the chapter on "Irregularities." Figs. 73, 74, 75, 108, and 109, as well as some other cuts in that chapter, exemplify conditions in which the difficulties of extraction are increased. It often becomes necessary to extract such crowed teeth for the relief of pain or cure of irregularity. It is impossible to lay down minute rules for guidance in all these diverse conditions. The general principles which always govern the operation of extraction must be borne in mind and the procedure varied to meet the exigencies of cases. It will be often necessary to grasp the tooth in an unusual position, often necessary to apply the force in an unusual direction. These are cases in which the operator cannot act with too much circumspection and caution. It will be often

necessary to employ unusual instruments; and most frequently a powerful narrow-bladed root forceps will take the place of the ordinary instrument. Special forceps having one blade narrow to act upon the crowded surface are provided for some cases. These are shown

FIG. 267.

FIG. 268.

in figs. 267 and 268. The narrowness of the blade increases the danger of crushing the crown; the force must be therefore applied with the utmost deliberation. It is also necessary to guard against injury or dislocation of adjacent teeth both in applying forceps and in moving the condemned tooth.

Abnormal Teeth.—Although it has been almost sufficiently pointed out that teeth of the same class vary so much in the form of their roots in different instances that the operator must be prepared for difficulties or ready to modify procedure in all cases, the foregoing description of the operation of extraction has been mainly based on the supposition that the teeth to be removed were not of extraordinary or highly abnormal character. It must be now more particularly pointed out that greater difficulties may arise in consequence of extremely irregular formation of the roots. Thus they may be so curved, or, in the case of molars, so spread as to require much more than ordinary force to remove them ; indeed, the roots are sometimes so placed in the jaw that it is impossible to remove the tooth without snapping one or more of the roots or breaking away a portion of the alveolus. The shape of many roots renders impossible their removal unless piecemeal. The portion of the alveolus most liable to be thus fractured is the septum between the roots of the molars, and especially the lower molars. The roots of these teeth, wide apart at the neck, sometimes converge towards their apices, and cannot be separated from the plate of bone which they enclose.

If unusual resistance be met with, an abnormal arrangement of the roots may be suspected. Such being the case, the operator must proceed cautiously and deliberately to exercise a sufficient amount of force to overcome the obstruction ; and as it is impossible to ascertain the precise form of the irregularity, it will be found safer in applying this extra force to follow the instructions given for the extraction of a normal tooth, slowly, cautiously, and deliberately applying force in accordance with the direction in which resistance is encountered. In spite of due care it must—as just

explained—happen occasionally that a portion of a root is left in the socket. The broken piece is sometimes loosened, and may be picked out with the root-forceps or elevator; but should the fragment, consisting only of the apex of the fang, remain fixed in its original position, it may be in some cases better to leave it rather than to inflict the injury upon the bone which its withdrawal would entail. It rarely gives rise to irritation, but in due course the changes which take place in the surrounding bone lead to its loosening or extrusion.

FIG. 269.

FIG. 270.

FIG. 271.

Drawings of abnormal teeth on previous pages, figs. 45 to 50, will suggest difficulties which may occur in extraction, and figs. 269, 270, and 271 may serve sufficiently to further exemplify this subject. The size, shape, and curvature of roots, it may be repeated, vary so extremely that it is impossible to typify variations.

The canine, fig. 271, obviously could not be removed without either leaving the curved extremity behind in the socket or extensively breaking away the investing bone. The lower molar, fig. 207, page 420, exemplifies "dovetailing" of the roots of these teeth within the bone, which occasionally occurs. The presence of exostoses at the apices of the fangs of this specimen would render its

removal entire hardly possible. Figs. 208 and 270 exhibit upper molars with similar irregularity of the roots, and fig. 269 depicts an upper molar of great size with unusually divulgent roots. The difficulties which might present themselves in extraction of teeth organically united to their neighbours by exostosis, as illustrated in figs. 209, 210, and 211 are sufficiently obvious.

The teeth shown in the reproduced photographs, figs. 204, 205, 206 (page 420), and 272 and 273, were all extracted intact and without any except trivial injury to the alveolus in one instance. These cases exemplify what may be done by deliberate application of force gradually and steadily increased. By this means the bone may be often made to yield and teeth drawn which rough efforts would surely splinter. The injury to the alveolus occurred with the lower molar, fig. 206. In this case the septum of bone passing between the roots was brought away—an accident evidently impossible to avoid, and one of no practical importance. All these teeth were removed by forceps except the lower wisdom tooth, fig. 272. This was forced out with the elevator, and well illustrates the utility of this instrument. It would have been difficult, if not impossible, to draw this tooth with forceps. It was quickly turned out of the socket with comparative ease in two or three efforts with the elevator, the instrument being thrust deeper and deeper as the root emerged.

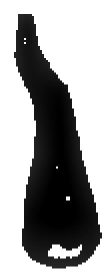
It sometimes happens that a molar with abnormal roots may be loosened, so as to move readily from side to side, but yet cannot be drawn by any amount of force which can be safely applied. In such cases the fangs of the teeth should be separated by cutting-forceps, shown in figs. 260, 261, and 262, and removed one by one.

The Casualties of Tooth-Extraction.—From the preceding description of the operation it may be inferred

that minor trivial casualties during extraction must occasionally happen, even in the hands of the most experienced, and that therefore more serious accidents are likely to occur frequently in those of the reckless and unskilful.

The following list, compiled by the late Mr. Salter, probably includes every variety of accident of this kind on record. Several of them have been already sufficiently referred to; others it will suffice merely to enumerate; the remainder will bear some further observations:— 1. Breaking of tooth. 2. Breaking of jaw. 3. Taking out wrong teeth. 4. Taking out two teeth instead of one. 5. Removing capsule of growing permanent tooth

FIG. 272. FIG. 273.



in extracting its temporary predecessor. 6. Tearing gum. 7. Wounds produced by slipping of elevator. 8. Extracted tooth falling into air passages. 9. Extracted tooth falling into pharynx and being swallowed. 10. Crushing the inferior maxillary nerve. 11. Dislocating the lower jaw. 12. Breaking one tooth in extracting another. 13. Cutting lip in removing a jagged extracted tooth. 14. Forcing tooth or tooth-fang into the antrum. 15. Forcing tooth-fang into an abscess excavation in maxilla.

Breaking Tooth.—Forceps being carefully applied, the deepest possible grip having been obtained upon the

tooth, and the force necessary to loosen it being carefully and deliberately exercised in the proper direction, it will nevertheless sometimes occur, even in the most skilful hands, that the tooth will break—more or less of the roots remaining in the socket. This may be due to the extent of decay (which may not have been entirely ascertainable before the operation), which has rendered the crown and neck of the tooth too weak to stand the necessary strain, or it may happen because the roots are so spread, or bent or twisted in shape, that it is physically impossible they can pass from the alveolus intact. Previous examination will in some cases have prepared the surgeon for the occurrence of the accident, and he may often be able to recognise on the instant whether the remaining fragments of root have been loosened by his efforts or partly withdrawn from their sockets. Readiness to deal on the instant with the varying conditions presented under the circumstances, to perceive the uselessness of further immediate action, or to apply without hesitation stump forceps or elevator and complete the operation, can only be acquired by experience. Rather than make ill-directed efforts, giving rise perhaps to severe suffering and injury, the operator had better pause whilst a careful examination is made. The extracted portions may indicate how much remains in the jaw. Exploration of the socket will show whether the fragments are loose, and whether they remain in the depths or are partly withdrawn. It is, of course, as a rule, desirable to extract every fragment of the condemned tooth, and the attempt should be persevered in to a due degree; but it must be obviously better to leave the deeper portions of roots for a time rather than risk the infliction of great injury upon the socket by prolonged efforts and use of great force. Moreover, it may be recollected that

in cases of disease extraction of the greater portion of a tooth will in most cases suffice for the temporary, if not permanent, relief of the suffering for which the operation is demanded. This will be more particularly the case where the pain has arisen from inflammation of the pulp. Where periostitis is the disease pain is more likely to persist. The roots are, however, usually more easily extracted (as was previously explained) where inflammation to any great extent exists around them. But even in these cases urgent symptoms are often sufficiently mitigated by removal of the bulk of the tooth. This often suffices to give vent to pent-up pus and exudations, to excite bleeding and otherwise relieve the tension within the alveolus to which the pain is mainly due.

Broken Tooth and Pulp left.—In cases in which the crown of the tooth is broken away, with or without a portion of root, it mostly happens that the pulp comes away with the extracted portion; but in some instances the whole or a part of a living pulp remains attached to the broken roots within the socket. A pulp so exposed is exquisitely sensitive, and if left becomes often rapidly inflamed and gives rise to severe pain. If for any reason it is not desirable to extract the roots, the exposed pulp should be scooped away with a large keen-edged, spoon-bladed excavator. As the pain of this operation is extreme, a general or local anæsthetic ought to be used. Free swabbing with a solution of cocaine, twenty per cent., answers well. Pure carbolic acid carefully applied, so as not to injure the surrounding parts, may be used for the same purpose. The acid diminishes sensibility and helps to destroy the pulp.

Breaking of Jaw.—Fractures involving the alveolus only to a slight extent occasionally occur, and are rarely followed by an untoward result. Fractures extending

through the ramus of the lower jaw, or completely severing a considerable portion of the upper maxilla, have in rare instances been caused by the extraction of a tooth. This accident might happen either in consequence of inherent weakness of the bone or the existence of some abnormal form of the fangs of the tooth, such as already exemplified. This accident, like most of those in the above list, could be guarded against only by the application of the principles already inculcated in the general observations upon extraction of teeth. The treatment of fractured jaw due to this cause, which would not differ from that arising from other forms of violence, is described in another chapter.

Taking out wrong Tooth.—The possibility of the occurrence of this accident has been referred to in previous sections. Patients thus frequently present themselves and request that a certain tooth be extracted which on examination is found to be sound, or at least not the source of pain. In all cases in which doubt exists, a careful inspection must be made to discover the offending tooth before an operation is attempted. It is often very difficult for a patient exactly to localise the seat of his trouble, and mistakes must occur when minute examination is omitted. The extraction of a wrong tooth in consequence of the slipping of the instrument is an inexcusable accident. Should the instrument become displaced, the operation must be stopped until it is readjusted.

Taking out Two Teeth instead of One.—The accidental extraction of two teeth instead of one may occur when force, as in using the elevator, is improperly exerted on an adjoining tooth. Cases have been recorded (*Transactions of the Odontological Society*) in which this accident has happened, although the utmost care was taken to avoid it—the movement of the

condemned tooth forcing the adjacent one from its socket. The accident has most frequently happened in young and crowded jaws, and in cases where extensive caries of the mesial or distal surface of the first permanent molar had allowed the crown of the adjacent molar or bicuspid to fall somewhat within the cavity of decay and become impacted there. The accidentally extracted tooth, in such cases, should be instantly returned to its socket and pressed home. It will, in most instances, reunite within a few days, and remain apparently uninjured, although probably the pulp may die.

Some few cases are recorded in which, in extracting a temporary molar, the rudimentary permanent bicuspid, which lies within the diverging fangs of that tooth, has been also brought away. In such instances adhesion between the two teeth had probably existed as a result of previous inflammatory action.

Tooth Falling into Air Passages.—The danger of this accident is one to be guarded against, particularly when a patient is under an anæsthetic. In such cases teeth slipping from the forceps ought to be instantly removed from the mouth. Several cases have occurred in which a tooth in these circumstances has fallen, or been drawn, into the glottis and passed into the lungs; and within the last few years an instance occurred in which the blade of a forceps was removed (by Sir W. MacCormac in St. Thomas Hospital) by operation from the bronchus of a patient into whose trachea it had fallen in an attempted extraction of a tooth during which the instrument was broken.

Tearing Gum.—Laceration of the gum, which was common with the obsolete key, ought not to occur with the forceps. The blades of the forceps are always to be carefully insinuated between the gum and the tooth, and in this position, if the blades are properly sharp, they

very rarely fail to force the gum away. It sometimes happens, however, that a tooth or root, owing to chronic inflammation, has become attached to the gum or alveolar walls by strong fibrous adhesions, which are only discovered when, on loosening its bony connections and turning it out of its socket, the tooth still remains attached to the tissues of the jaw. In these cases, if the tooth were torn away, an extensive laceration of the gums might ensue. This is to be prevented by dividing the adhesions by a scalpel or scissors.

Crushing the Inferior Dental Nerve. — Several cases have been reported in which, after the extraction of a lower molar, sensation was lost at that part of the face supplied by the inferior dental nerve, which had evidently received some injury in the operation. This accident would arise from abnormal proximity of the nerve to the fang of the tooth.

In one case (described on an earlier page*) the roots of a lower wisdom tooth contained a groove and a foramen through which the inferior dental nerve had evidently passed. Complete loss of sensation over the region supplied by the nerve occurred at once on extraction of the tooth, but after lapse of a few months sensibility was again slowly but completely restored. No treatment was attempted.

Pain following the Extraction of a Tooth is usually slight and soon subsides unless periostitis exist. When this is present pain frequently, although not invariably, follows the operation, but this in slight cases mostly subsides within half-an-hour. Indeed, the removal of the tooth, by giving vent to exudations and relieving tension, very often puts an end at once to the pain of acute periodontitis. When pain continues, no inflammation having been present, it will sometimes be found to be due

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* See Chapter on "Neuralgia."

to bending outward or partial fracture of the alveolar walls; whereby the periosteum is torn or stretched. This condition is often easily recognizable, particularly when a sharp margin of bone may be felt through the overlaying gum. Sometimes upon this injury, and occasionally in cases where none can be perceived, extremely painful but slight inflammation, mostly limited to the alveolus, supervenes. This may last some days, but rarely takes a bad course.

The inflammation in many cases seems mainly to affect the interior of the alveolus, and it is possible in some cases it may be due to the bending or fracture of the bony septa which divide and pass between the roots—bending which cannot by any means be avoided.

If bending out of the alveolar plates is detected it should be reduced by firm pressure between the thumb and finger. This is mostly a very painful procedure, and an anæsthetic may be called for. It is a good rule of practice immediately after extraction of a tooth to close the alveolus in this way if the walls seem at all bent outwards. On withdrawal of the tooth the fingers may be at once applied and the procedure carried out before the patient recovers from an anæsthetic.

Inflammation of the alveolus and neighbouring bone is best treated with hot fomentations within the mouth and warmth without. Relief is afforded in some cases by frequent free syringing of the alveolus with water as warm as can be comfortably borne. Considering the amount of force exercised in the operation, it seems marvellous how few are the cases in which severe or extensive periostitis follows tooth extraction. The rare cases in which it occurs calls for the treatment described in a previous chapter.

Hæmorrhage which follows Extraction of Teeth in most cases is extremely slight, and usually ceases

within a few minutes. Occasionally, however, oozing goes on for a considerable time, whilst in rarer instances the flow is so severe as to require active measures for its arrest. The bleeding may be due to hæmophilia, or may result from laceration of an artery. The former variety, which usually takes the form of general capillary oozing, is by far the more common, but the latter, in which the blood issues in a jet, or in a full florid stream, is, although extremely rare, not unknown. The vessel liable to be wounded in extracting a tooth is the dental artery, or one of its branches, which may run in abnormal proximity to the root. In consequence of periostitis which has existed for a long period, capillary vessels, previously too minute to give rise to more than trivial bleeding, may become enlarged, so as to pour out when lacerated a considerable stream. It occasionally happens that hæmorrage, which has ceased for a time after the extraction of a tooth, recurs after an interval of hours or days, and this frequently happens with patients of the hæmorrhagic diathesis. Bleeding is apt to recur when the patient becomes warm in bed.

Treatment.—Slight hæmorrhage may be usually arrested by cold—the mouth being freely rinsed with cold water, or better with iced water; and cases which call for other measures beyond this are exceptional. Should the flow persist in spite of these measures, or should it be copious or arterial in character, the alveolus must be firmly plugged. The clots having been removed by syringing with cold water, a narrow strip of lint or a lightly twisted rope of absorbent cotton-wool is tightly packed into the alveolus by a blunt probe, fold upon fold, care being taken to pass it to the bottom of each division of the socket. This if effectually done will in most cases suffice, but if the bleeding continue from the margins of the socket a small compress of lint is placed

in position, and pressure is kept up by causing the patient to bite forcibly upon it, and fixing the jaw by a bandage passed over the head and beneath the point of the chin. If greater pressure is needed a piece of gutta percha may be softened, and the patient be made to bite it forcibly upon the compress. A cork cut to shape answers the same purpose. Should the bleeding be severe, should much blood have been lost, or should there be reasons which make desirable the more certain instant stoppage of the flow, the plugs on insertion and compress may be charged with tincture of perchloride of iron or other styptic. The plug—which sometimes gives rise to irritation—may be carefully withdrawn after the lapse of twenty-four to forty-eight hours.

Seeing how effectually pressure may be maintained npon the whole bleeding surface by plugging the socket in the manner described, the instances must be extremely infrequent which call for other treatment. Such cases are, however, recorded. In these cases a cast of the part might be taken, and a silver plate be struck up to cover the alveolus and the neighbouring teeth, extending well over the sides of the jaw, and leaving room for a lining. The alveolus being tightly plugged with styptic and wool, and a small compress applied, the plate, lined either with lint or softened gutta percha, would be then pressed into place.

Instances, although few and extremely rare, are recorded in which, after extraction of a tooth, every effort to arrest the hæmorrhage, including the last resource—ligature of the common carotid artery—failed, and the patient at last perished from loss of blood. In these cases (none have been reported in late years) the patients were highly hæmorrhagic, and in some of them injury—extensive laceration of gum—had been inflicted

either in extracting the tooth or in attempts to arrest the bleeding afterwards.

Extraction of Temporary Teeth.—The evils resulting from premature extraction of temporary teeth have been pointed out in preceding chapters. Instances are extremely few in which extraction is really called for before the teeth have become loosened by absorption of their roots, unless they are the seat of necrosis or incurable alveolar abscess. The method of operating is exactly the same as for permanent teeth; and although special forceps may be occasionally useful, a pair can be usually found among the ordinary set to answer all purposes. It must be remembered that the roots of the molars are much spread, and if they are entire the extraction of a tooth will need considerable force. This must be applied with caution lest the alveolus be badly broken or the underlying permanent bicuspid disturbed. For detaching loose crowns, and picking out necrosed roots and fragments from the gum, a light stump forceps or an elevator answers admirably.

DISLOCATION AND FRACTURE OF THE JAW CLOSURE OF THE JAWS.

Dislocation and fracture of the jaw—subjects dealt with fully in surgical works—are, except in so far as they immediately concern the dental surgeon, outside the scope of this book.

Dislocation is not likely to be brought before the dental surgeon unless as an accident occurring under his own hands. It may happen during filling or extracting lower teeth, but is barely possible when due care to fix and support the bone is exercised. A jaw which has been dislocated is, however, very apt for some long time afterwards to slip out when the mouth is widely opened —as, for instance, in yawning—and therefore great care must be taken whilst operating on the teeth, especially on those of the lower jaw, of a patient who has suffered this injury.

Diagnosis.—The diagnosis can hardly be mistaken, particularly by a witness of the accident. The jaw is fixed and protruded and the mouth wide open; the flow of saliva increases, and the patient, having difficulty in swallowing, it dribbles from the mouth; articulation is difficult; the dislocated condyles can be distinguished by the fingers and a characteristic hollow may be perceived behind them. In rare cases the dislocation is unilateral.

Treatment.—To reduce the dislocation the surgeon firmly grips the jaw with one hand at either side, the thumbs being within and with their points applied upon

the second molar and wisdom teeth. Pressure downwards is then exercised by the thumbs, whilst the chin is drawn upwards and a little forward. The dislocation seldom presents great difficulty, but in some few cases ether or chloroform may be needed either to spare pain or to cause muscular relaxation. The thumbs of the operator must be protected by thick bandages lest they be crushed by the teeth, which come together with force as the jaw springs into place.

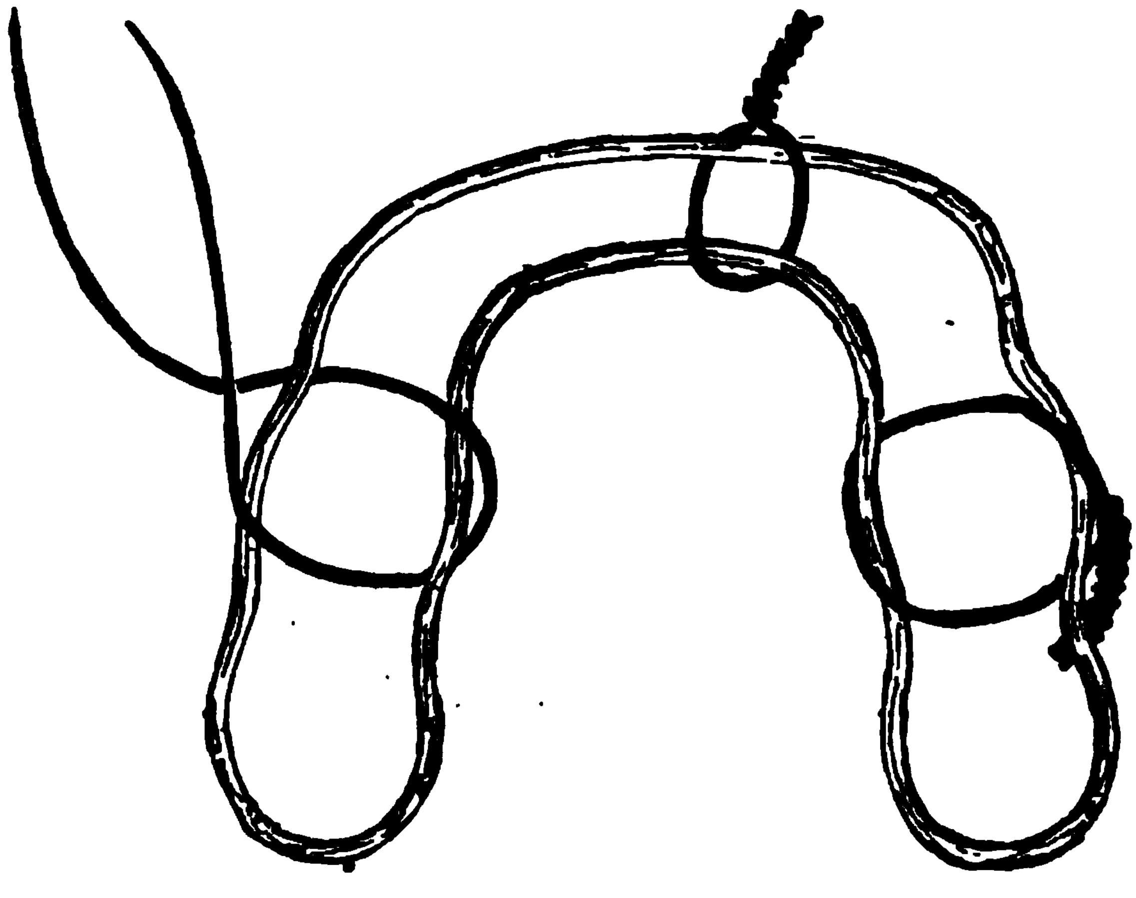
Fracture of the Jaw is not within the sphere of dental surgery, but it has now become recognised that in some cases the dentist can do much in conjunction with the surgeon to render treatment more simple and certain, and to save suffering and disfigurement to the patient.

The Diagnosis of fractured jaw is simple. The history of the case rarely leaves room for doubt. The characteristic symptoms are increased mobility, deformity and crepitus. The most common seats of fracture are through the socket of the canine tooth, and through the mental foramen, the relative frequency being in the order here indicated. Fracture through the symphysis, at the angle of the jaw, through the neck of the condyle, and through the coronoid process, though of occasional occurrence, are comparatively rare.

Treatment.—Simple uncomplicated cases can be of course successfully treated by the old-fashioned gutta-percha outside splint and bandages; but even in these cases the dentist may be of great service. He can as a rule at once so fix the broken bone that the patient may from the first open his mouth to drink and eat—although of course he cannot masticate perfectly—and may be saved the discomfort, otherwise often unavoidable when the jaws are kept closed, of living for some weeks upon fluid sucked through the interstices of the

teeth. The application of dental splints can be effected in simple cases by a surgeon; but even in the simplest cases the dentist may be useful. He can judge which teeth will best stand the strain of the dental splint and can avoid injury to delicate and stopped teeth. His services will also often be needed to deal with teeth broken or partly dislocated. Where the bone is fractured in more than one place, and where fragments

FIG. 274.



are with difficulty kept in position, the services of a dentist become almost indispensable.

The simplest instrument for treatment of fractured jaw is the wire splint devised by Mr. Hammond (figs. 274 and 275).* By means of this apparatus the broken fragments can be at once permanently and immovably fixed. The splint takes up no appreciable room, and can with ease be kept perfectly clean. To make this splint a

* These drawings by Mr. Hammond show the exact sizes of wire which he recommends for splints and ligatures.

cast of the upper and lower jaws must be made. The teeth next the line of fracture are first ligatured with silk to steady the fragments. Wax may be used for the impressions which need not be deeper than the teeth; and if owing to swelling and pain there is difficulty in using a whole tray for the fractured jaw, half trays may be used. In some cases an anæsthetic may be needed in this part of the operation. If the cast shows displacement, it is sawn apart and then fixed anew in position, guided by the bite of the upper model. A stout iron wire frame of the thickness depicted in the cuts is

Fig. 275.

then moulded to the necks of the teeth and the ends soldered with silver solder. At some hospitals sets of splints in a few different sizes are kept in readiness; and it is found that one can usually be picked out to suit—with a little fitting -the majority of cases.

The splint is placed in position and secured by ligatures of thin iron binding wire round the necks of as many sound teeth as may seem necessary. The method of applying the ligatures, of securing them and turning the ends out of the way is made very clear by figs. 274 and 275. It may be sometimes necessary to scale the teeth to facilitate passage of the wire through the

spaces. It is well to tighten up the wires gradually on either side so as to equalise the strain, and the ligatures may need further tightening after lapse of a few days. An antiseptic lotion and a very soft tooth brush may be used to keep the parts clean.

The Gunning splint, fig. 276, is in many respects a most excellent apparatus.* It consists practically of two parts joined together. Fixation of the broken fragments is gained by means of a vulcanite cap fitting over the teeth and alveoli of the upper jaw; a similar cap fitting

FIG. 276.

the fractured jaw is vulcanized to the first, space being left between the two for the purpose of cleansing the mouth and of feeding. When necessary the splint may be lined with gutta percha. The gutta percha being softened by heating, the splint is pressed into position, the jaws closed upon it and retained in the closed position by means of a four-tailed bandage.

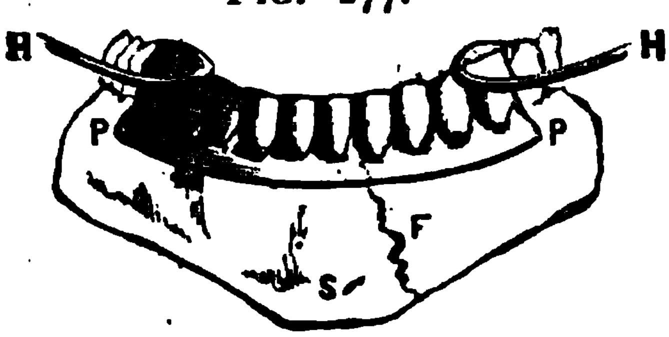
Mr. Hayward's splint is illustrated in fig. 277. It consists of a metal cap fitting over the teeth and gums on either side of the fracture. To the upper surface of the plate are fixed two pieces of stout wire, curved to

* Figs. 276 and 277 are kindly supplied by Mr. Christopher Heath, from his work on "Injuries and Diseases of the Jaws."

permit their passage round the angles of the mouth. These wires are attached by a bandage to a gutta percha splint moulded to the external aspect of the jaw.

It occasionally happens, especially when fracture at more than one place has occurred, that the difficulties to be overcome to retain the portions of the fractured mandible in position are greatly increased. When this is the case it sometimes answers best to fix the broken fragments by wiring them together. Several methods of performing this operation have been described. In their essentials they are similar. The following is a short description of the method employed by Mr. T. S. Carter, of Leeds.* In this case the jaw was fractured

FIG. 277.



transversely across the ramus on the left side, also perpendicularly between the two fangs of the first molar on the same side, and likewise perpendicularly through the socket of the second bicuspid on the right side.

With a specially made bayonet-shaped drill, driven in the dental engine, a hole was made through the jaw between the first and second molars. An oral spoon guarded the tongue from being wounded by the drill. A stout silver wire was next passed through the drilled hole, and a second hole bored between the fang of the canine and the first bicuspid. The wire having been brought through the second hole from the inside, the ends were twisted together and tightened with pliers; the tail thus

* "Lancet," December, 1892.

formed was bent down flat so as to be out of the way. The fracture on the right side was treated by a Hammond's splint. Mr. Carter points out that the chief difficulty is to return the wire after its passage through the first hole, and he points out that by bending a long loop on it, a fine wire passed through the second opening may be fixed to it and the stouter wire drawn through.

The treatment of teeth partly dislocated or fractured by the injury which has broken a jaw does not differ from that already described for similar injuries in previous paragraphs, but badly damaged teeth at the seat of fracture likely to excite inflammation or interfere with union of the bone may call for removal.

Fractures extending through the body of the upper jaw are very uncommon, and they can be caused only by direct violence of an extreme degree. A case of this kind is reported in the *Transactions of the Odontological Society*, 1889, by Messrs. Ewbank and Ackery, under whose care at St. Bartholomew's Hospital it came. In this instance both bones were fractured and laterally displaced by a violent blow from a heavily laden swing. A good recovery took place. The patient was a lad in his teens. The point most dealt upon in the treatment of this case was reduction of the displacement by means of the bite of the lower jaw, and fixation of the fractured bones by means of a modified Gunning splint.

Fractures involving the alveoli only are more common. They are due to the same causes and their treatment is similar. This consists in bringing the broken fragments into apposition, and securing them by wire ligatures passed round the teeth, or by a modification of the Hammond splint, or by a metal or vulcanite frame fitted to the palate and embracing the necks of the teeth behind. Such cases were referred to in the chapter on injuries to the teeth. The prognosis, particularly in

children, is favourable, except in cases in which the fractured portion of bone is entirely detached and the periosteum completely torn through. Under the latter circumstances necrosis is likely to follow.

Closure of the Jaws.—The only cases of this affection which are likely to come directly under the notice of the dental surgeon, or that have any relation to diseases of the teeth, are those which have been described in previous chapters as occurring in connection with impaction of lower wisdom teeth and with periostitis of the lower molars. The very rare affection closure due to tonic spasm of muscles has also been referred to in the same chapters. Other causes of closure are ankylosis following inflammation within and around the joint; and contraction of cicatrices within the mouth and cheek, the result of injury, or of ulceration such as cancrum oris attended with great destruction of tissue. The diagnosis of these cases presents no difficulty; examination reveals their nature, and there is besides usually a clear history of disease leading up to fixation of the bone. The treatment of ankylosis consists in dividing the bone as close to the joint as practicable, and removing a small piece. The aim then must be to establish a false joint. In closure due to cicatrices although the prognosis is not favourable—cases rarely yielding permanently to the treatment—an attempt is sometimes made to force the jaws gradually apart by mechanical means; and in the construction of instruments the dentist in these cases might give valuable help. These cases, if at all severe, are usually dealt with by Esmarch's operation. This consists in cutting out a wedge-shaped piece of the lower jaw—the apex in front—and then endeavouring to establish a movable false joint.

APPENDIX A.

BACTERIOLOGY OF THE MOUTH IN RELATION TO THE TEETH.*

THE wide distribution of micro-organisms in nature suffices to explain why bacteria and other fungi are so frequently found in the buccal cavity, communicating, as the latter does, with the outside world. Many of the mouth bacteria are, so far as is known, perfectly harmless, but others produce by their chemical activity destructive lesions of the teeth. Others are capable of setting up severe and even fatal diseases. The buccal cavity is, in fact, one of the chief portals of invasion for pathogenic microbes; and as the most important diseases of the teeth are, directly or indirectly, due to micro-organisms, a study of the latter has come to be recognised as of fundamental importance in dental science.

Micro-organisms in the widest sense of the word are subdivided into four great classes, viz., Hyphomycetes (moulds), Blastomycetes (yeasts), Streptothriceae, Schizomycetes (fission fungi—true bacteria). Members of any or of all these divisions may be found in the buccal cavity, but the schizomycetes are unquestionably of most importance. The schizomycetes are usually subdivided into three families. Many of these organisms multiply by fission or division, others by endospore formation.

I. Coccaceae—in the free condition the cells are round. Division takes place in one, two, or three

* This Appendix is composed from notes kindly supplied by Dr. W. Bulloch, Bacteriologist to the London Hospital.

planes, so that diplococci, tetrads, or octads are formed. To this family belong streptococcus, micrococcus, sarcina.

II. Bacteriaceae—cells at least one and-a-half, usually two to six times as long as broad, straight or slightly curved in one direction. Division in a plane at right angles to the long axis.

III. Spirillaceae — cells bent or spiral usually elongated. Division always at right angles to long axis. This family includes vibrio, spirillum, spirochaete.

It is now generally accepted that micro-organisms belong to the division of fungi, the fungi being distinguished from other plants mainly by the absence of the green colouring matter—chlorophyll. This is a fundamental factor in their life history, for whereas chlorophyll-bearing plants are able to obtain their carbon and nitrogen from carbonic acid, ammonia and nitrates, and of building up their complicated carbon and nitrogenous compounds from these relatively simple substances, fungi require already-formed organic compounds. In obtaining their nourishment fungi split up these organic compounds into simpler bodies by a process of fermentation, the actual fermentation in many cases being brought about by soluble ferments. In other cases the ferment does not exist apart from the actual living protoplasm. From a dental point of view the study of these fermentative processes is of cardinal importance.

In general, enzymes or ferments are soluble in water, and insoluble in alcohol. They are very susceptible to the influence of external agents. The temperature at which they are most active varies, but above 70°C. all ferments are rapidly destroyed. The general action of ferments is one of hydrolysis, the molecule of the substance to be fermented taking up one or several molecules of water,

and becoming split up into one or two molecules. The chief bacterial soluble ferments are:—

I. Proteolytic.—These convert insoluble proteids into soluble diffusible products. Such ferments occur in the gastric (acid) and pancreatic (alkaline) juices. In the case of most bacteria the proteolytic ferments are bacteriotrypsins, acting in an alkaline medium.

II. Ferments which break up carbohydrates and their derivatives.

A. Diastatic ferments (amylases).—Analogous to ptyaline of saliva and diastatic pancreatic ferment. They convert starch into sugar. This is rare among bacteria.

B. Inverting ferments convert disaccharides (cane sugar maltose) into simple hexoses (? glucose).

The nature of the products of fermentation is very important as regards the action on the teeth. If *acid* is formed it may lead to decalcification of the enamel. The type of this fermentation is seen in the case of the conversion of grape sugar into lactic acid. Cane sugar and lactose are first inverted and then fermented.

$$C_6H_{12}O_6 = 2\ C_3H_6O_3 \text{ (lactic acid).}$$

This simple equation is, however, not quite correct, as not all the sugar is converted into lactic acid. Some of it is transformed into other products which may be acid. This lactic acid fermentation is a property possessed by a large number of bacteria. It proceeds best about the temperature of the human body, and therefore well in the mouth where there is sufficient sugar, derived partly from the food and partly from the conversion of starches into sugar by the ptyaline of the saliva. A large number of mouth bacteria were found by Miller to induce the lactic acid fermentation.

Putrefaction is the fermentation and breaking up of the proteid substances by bacteria. The term is applied

especially to those cases where the products of the fermentation are gaseous and foul smelling. The exact chemistry of the deconstitution of the proteid molecule is not yet known. A very large number of compounds are formed, the first products being rapidly split into simpler bodies. Apparently the first change is a process of hydrolysis, the proteid becoming converted into albumoses and peptones, these latter being rapidly changed into—

1. Amido derivatives of the fatty acids.
2. Nitrogen-containing bodies of the aromatic series

Subsequently the amido acids give off ammonia; and the fatty acids which are set free break down into carbonic acid, hydrogen, marsh gas, etc. Acids are also formed in considerable quantity, especially formic, butyric, lactic, acetic, acrylic. In the earlier parts of the process a number of poisonous basic bodies are also produced. These are the so-called ptomaines or poisonous alkaloids. This process of putrefaction plays an important rôle in dental pathology, and the absorption of poisonous products from gangrenous pulp cavities, foul abscesses, and other septic sources, may lead to serious consequences.

In estimating the effect of bacteria in the mouth and teeth the relation to oxygen is of some considerable import. Usually from this standpoint bacteria are divided into three classes:—

I. Obligate Aerobes.—Here growth ensues only when there is plenty of air.

II. Obligate Anaerobes.—Growth takes place only when oxygen is absent.

III. Facultative aerobic and anaerobic bacteria. These grow both in the presence and absence of oxygen and the group includes most of the pathogenic varieties.

In regard to the general rôle played by bacteria in respect to dental diseases, one must distinguish another action, viz.—pathogenic.

Pathogenic effect.—The disease producing properties of infectious bacteria are the result of two actions, viz.—the rapid and extensive multiplication of the bacteria, and the production of soluble poisons, and one may theoretically distinguish between infection and intoxication, although the two processes are often combined.

FIG. 278.*

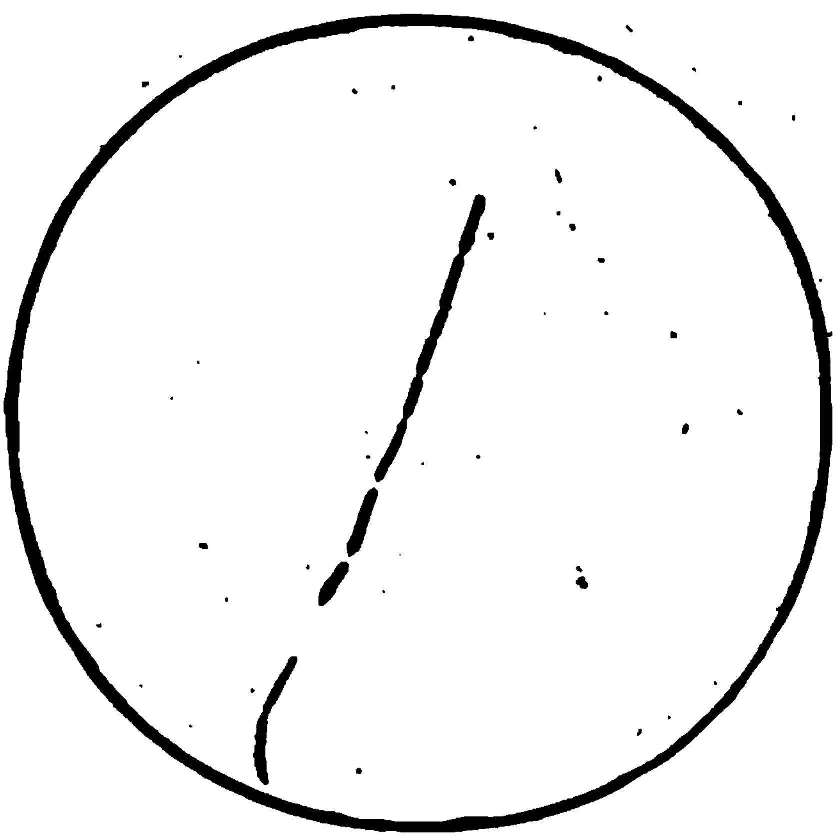
Spirillum Sputigenum. × 1000.

There is also a considerable variation in the virulence of pathogenic bacteria; and apart from this is the susceptibility of the individual. In regard to the effects of pathogenic microbes it is important to remember that the same bacterium may cause a number of different lesions and the same anatomical lesions may be caused

* Figs. 278, 279, 280 and 281, are from cultures prepared by Dr. William Hunter, Assistant Bacteriologist to the London Hospital.

by quite a variety of different microbes. The reasons for these differences appears to be the variety of the site of the inoculation, and the quantity and the quality of the virus. Many of the bacteria in the mouth are harmless, or act only by producing by-products which may lead to decalcification of the enamel and dentine. Others may produce local disease of the vascular connections of the teeth or of the tissues of the mouth itself; others again may induce severe general disease

FIG. 279.



Bacillus Buccalis Maximus. × 1000.

or even rapidly fatal septicaemia. The complete study of the bacteriology of the mouth is very complicated, and reference should be made to important works such as Miller.* Some characteristic bacteria are met with in the mouth, but so far a definite pathogenic action has not been attributed to them. What is described as

* Die Bakterien der Mundhöel. Berlin, 1894. Second Edition.

leptothrix buccalis is a thread-like organism which is not specially characteristic. Miller describes other ill-defined varieties such as lepothrix gigantea, leptothrix maxima buccalis, leptothrix innominata, and bacillus maximus buccalis.

Iodoccus vaginatus is a rounded organism arranged in chains; the organism itself may be stained blue with iodine.

Spirillum sputigenum is a curved organism which is

FIG. 280.

Streptococcus Brevis. × 1000.

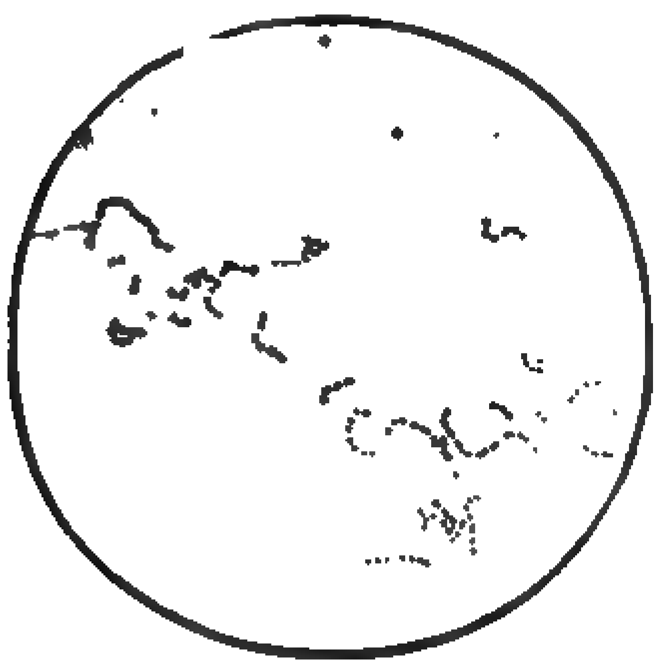
frequently found in the healthy mouth and also in carious teeth.

Spirochaete dentium is a special organism frequently found at the juncture of the tooth and gum.

II. Pathogenic bacteria.—The mouth may contain a large number of pathogenic bacteria causing local or general disease, and there is also reason to believe that many of these organisms play an important part in many

dental diseases. The various pyogenic cocci, especially streptococcus pyogenes, micrococcus pyogenes aureus, albus and citreus are frequently met with. Streptococcus lanceolatus (pneumococcus) and bacillus of Friedländer are also common, especially the former. B. diphtheriae is an important organism and may indirectly affect the teeth, especially from its frequent association with pyogenic microbes. Recently Arkövy has drawn attention to the frequence of a peculiar organism—the

FIG. 281.



Streptococcus longus. × 1000.

B. gangrenae pulpae in gangrenous pulpitis. The organism is found in the form of large rods 4 μ long and 0·8—1 μ wide, and it exhibits marked motility; it forms large oval spores and it grows well on all media. This is apparently often found in pure culture in gangrenous tooth pulps. The common organism of putrefaction (*proteus vulgaris*), is also frequent.

APPENDIX B.*

METHODS OF PREPARING SECTIONS OF CARIOUS TEETH FOR MICROSCOPICAL EXAMINATION.

Mr. Arthur Underwood prepared a vast number of sections by the following simple method. The sections were hand cut from recently extracted teeth without any preliminary preparation whatever. A Baer's knife was used; the tooth being held in one hand, the knife in the other. With a little practice it is possible to slice off from the carious tissues sections of sufficient size (very small pieces serve the purpose) and thin enough for high-power examination. The sections were stained by immersion in methyl violet; or, if for photography, Bismark brown. Staining occupies about five minutes, at the end of which time the sections will look dark. They are next immersed in water (a watch-glassful) in order to wash out excess of dye. When the colour becomes faint purple or brown the sections are dried on blotting-paper. They are next dehydrated by immersion in spirit, but as this is apt to abstract dye, watchfulness must be exercised—from two to five seconds usually

* Appendix B appeared in the third edition, and it has been thought well to re-produce it as it describes the methods used in preparing the sections from which the description of caries was written for this work.

To carry out the methods described some general knowledge of bacteriological microscopy is necessary. This may be obtained from current manuals.

suffices—and on withdrawal the drying is hastened by laying them on blotting-paper. They are lastly immersed in cedar oil to clear them, again dried on blotting-paper, and then mounted on slides with a drop of xylol balsam. The cover-glass ought not to be thicker than ·004. With this method of preparation Mr. Underwood was able easily to demonstrate micro-organisms under $\frac{1}{12}$ objective (oil immersion).

Using the method which Mr. Pound and Mr. Sewill adopted, the following materials are needed:—Absolute alcohol. Commercial alcohol (methylated spirit). Distilled water. Aniline oil. Carbolic acid. Potassium iodide. Iodine. Clove oil. Xylol. Canada balsam (dry). Shellac. Gentian or methyl violet. Fuchsine. Acid rubin and orange. Gum acacia. Swedish filter paper. Best thin slides and No. 1 glass circle covers.

(1.) *Formula of Gum Mixture for Freezing.*—Gum, 1 oz., water 4 oz. When dissolved squeeze through muslin; then add camphorated spirit, 3 drops; and a few drops of carbolic acid to maintain the mixture aseptic.

(2.) *Aniline Gentian or Methyl Violet (Gram.)*—Saturated emulsion of aniline oil and distilled water. Filter twice. Take 20 cc. (cubic centimetres) of the filtrate; add 1 cc. of a saturated alcoholic solution of gentian or methyl violet.

(4.) *Potassic Iodide Iodine Solution (Gram).*—Iodine, ·5 gramme. Potassium iodide, 1 gramme. Distilled water, 150 cc. Add 20 cc. of water first, and when dissolved by shaking, add remainder.

(5.) *Xylol Balsam.*—Balsam Canadensis (dry), dissolved in xylol (pure) to consistency of honey or syrup. After standing for a week or ten days, all dirt and *débris* will have become deposited; then decant off the clear solution into stoppered bottle.

(6.) *Shellac Varnish.*—Shellac, 1 part. Methylated alcohol, 4 parts.

(7.) *Strong Acid Rubin and Orange* (*commonly known as Rubin S.*)—Acid rubin, saturated aqueous solution, orange, saturated aqueous solution. Mix equal parts.

(8.) *Dilute Acid Rubin and Orange.*—Add 1 cc. of No. 7 to water, 12 cc.

(9.) *Carbolic Fuchsine, Ziehl's*—Fuchsine, 1 gramme, dissolved in absolute alcohol, 20 cc. Add carbolic acid 5 per cent., 100 cc. Before using, diffuse green scum by addition of a little alcohol.

Teeth after extraction should be immediately placed in alcohol (methylated spirit) for seven to fourteen days, to harden the softer carious portions. When hard the carious dentine is cut out and soaked in water for twenty-four hours to get rid of the alcohol. Next it is immersed in gum mixture (No. 1) for twenty-four hours. Sections are then cut with Swift's ether freezing microtome, and then rinsed in water for a few minutes to wash out gum.

From water the sections are put into aniline violet solution (2) for three to six minutes, and then transferred to iodine solution (4) for two to four minutes, or till they turn brown. Next they are transferred direct to alcohol (not absolute), and washed till they appear completely decolorised. They are then washed in fresh alcohol, clarified in clove oil, and placed on a clean slide. All clove oil is now to be removed by carefully pressing filter paper on the section. Lastly a drop of xylol balsam is added, and a No. 1 cover glass is applied.

The aniline violet solution stains both organisms and tissue, and by the iodine solution the colour is fixed in the organisms—the solution contracting and at the same time fixing the stained protoplasm within the sheath of the organism. When once the stain is thus fixed the

colour can be washed out of the tissue by means of alcohol.

When such a specimen after being mounted is examined under a suitable microscope, such as a Zeiss or the Swift's (Crookshank Model), with a 1 in. objective, blue streaks are seen. These on examination under a $\frac{1}{6}$ inch objective (Swift's) are definable as the case may be into masses of leptothrix, bacteria, or micrococci within the dentinal tubes. An Abbé's sub-stage condenser is almost indispensable. If the morphology of the organisms is to be studied, a $\frac{1}{12}$ homogeneous immersion objective will be required.

If the structure of the tissue is to be brought out, sections should, after coming out of alcohol, be placed in rubin and orange stain for five minutes, then washed in distilled water, dehydrated in alcohol, clarified in oil of cloves, and finally mounted in xylol balsam. In this procedure it is best to overstain the sections somewhat, and afterwards correct it by rinsing in water.

This method brings out the structure picture, especially in transverse sections. In some parts the tubes will be blocked with organisms, in another part tubes appear apparently healthy. In other parts the "pipe-stem" appearance is seen. Sometimes in vertical section stained with rubin S. globular dentine is well shown.

Cover-glass preparations of scrapings from a carious tooth when stained simply by carbolic fuchsine show appearances different from those produced by Gram's method. When stained by carbolic fuchsine the characters are not at all altered. By the Gram method, however, the organisms do not appear so thick; also other typical points and minute details are not shown.

When sections or cover-glass preparation on coming out of aniline violet are placed in iodine solution this acts as a mordant, and sudden contraction of the proto-

plasm takes place, which of course alters the minute characteristic details of the organisms. This is easily demonstrated in the case of bacillus anthracis. On staining a blood preparation of this organism with fuchsine the characteristic square-cut ends can be distinctly seen, but after staining a similar preparation by Gram's method, the bacilli appear shorter and more slender and with distinctly rounded ends.

Rubin stain was first used in this country by Watson Cheyne, in combination with Ehrlich's hæmatoxylin, and is perhaps the best stain for pathological and histological purposes ever introduced.

It is necessary to preserve specimens that cover-glasses be thoroughly cemented with two or three coats of shellac varnish (6). Specimens not so guarded will fade, even if kept in the dark.

APPENDIX C.

ANTISEPTICISM IN DENTAL SURGERY.

THE practice of antiseptic methods in dental surgery is called for (1) in promotion of the general hygiene of the mouth, (2) in prevention of dental caries, (3) in combating septic conditions such as exist in consequence of vitiation of the secretions in systemic disease or local maladies attended with foul discharges. Since the aim in all these conditions is the same, namely, to destroy micro-organic life and to prevent putrefaction and fermentation, the same agents are almost equally useful in all. Lastly, antiseptic agents are called for in treating caries and its inflammatory sequels within and around the teeth.

These subjects have all been discussed under their respective headings in various chapters. It is proposed now merely to amplify such subjects as seem to need it; to mention some additional useful agents, and to add prescriptions of compounds found generally useful in practice.

The general hygiene of the mouth can be maintained in ordinary cases by aseptic means—by the practice of cleanliness without the aid of antiseptic agents. This subject was discussed perhaps sufficiently in the chapter on "Prevention of Caries." It must be borne in mind that for great masses of the people tooth brushes and tooth powders are unattainable luxuries. It would be a point gained if these classes could be taught the importance of keeping a clean mouth, and of frequently washing and gargling the cavity daily.

In gargling with either water or a lotion the mouth should be partly filled and the fluid forced to and fro between the teeth by the movements of the lips and tongue.

To maintain a high degree of cleanliness a tooth brush is indispensable; and with a brush and soap—to which many poor patients will not object—this can be achieved. One of the simplest forms of tooth powder is the mixture of precipitated chalk with soap powder, described in the chapter on "Prevention of Caries." This can be made more antiseptic by addition of carbolic acid, eucalyptus oil, and oil of cloves; and this addition, although it will not be agreeable to children and many women, will be appreciated by male patients who, as smokers, are used to pungency in the mouth.

In hospital practice and among the poor, antiseptic lotions need to be inexpensive. Chloride of zinc, in strength of ½ a grain to an ounce of water, is one of the simplest and least disagreeable of mixtures. Carbolic acid, with or without glycerine, may be used to a strength of one in fifty; or permanganate of potash (Condy's fluid) from half a drachm to a drachm to the ounce. This is one of the best agents for use with children. It is practically not poisonous and can be used, when needful, in full strength. A carbolic lotion may be made more agreeable by addition of a drachm or two of eau-de-Cologne or lavender water to the ounce.

Perchloride of mercury to a strength of one in five thousand may be made agreeable by use of orange flower water, or rose water with glycerine. In using this poisonous drug habitually care must be taken to prevent it being swallowed; and it is best, perhaps, to use it in solution in water, and to rinse the mouth freely with an agreeable lotion after each act of gargling; or, again, the solution may be used with a tooth-brush, and the mouth well washed frequently during the brushing. The mechanical sweeping of the teeth by a brush adds to the efficacy of all lotions.

The following prescriptions of antiseptic tooth-powders and mouth washes are largely based upon those formulated by Dr. Miller. These prescriptions may be used habitually; and those containing potent antiseptics, like perchloride of mercury, are specially intended for use where highly septic conditions exist as, for example, in pyorrhœa alveolaris.

℞ Thymol, gr. 1
Acid Benzoic, gr. 15
Tinct. Eucalypt., ʒ 2
Oleum. Gaultheria, ♏ 10
Eau de Cologne, ad ℥ 1
Misce: fiat lotio.
Half-a-teaspoonful to a teaspoonful in a wine glass of water.

℞ Acid Boric, ʒ 2
Magnes. Carb., ʒ 2
Menthol, gr. 8
Sapo. Castil, ʒ 2
Oleum. Gualtheria, ♏ 20
Acid Carbolic Liq., ♏ 15
Creta. Precip., ℥ 1
Misce: fiat dentifric.

℞ Thymol, gr. 1
Acid Benzoic, gr. 15
Hydrarg: Perchlor., gr. 2
Oleum. Gualtheria, ♏ 10
Eau de Cologne,
Alcohol, āā ad ℥ 1
Misce: fiat lotio.
Half-a-teaspoonful to a teaspoonful in a wine glass of water.

℞ Thymol, gr. 5
Acid Carbolic Liq., ♏ 10
Tinct. Anisi., ʒ 1
Alcohol, ad ℥ 1
Misce: fiat lotio.
Half-a-teaspoonful to a teaspoonful in a wine glass of water.

℞ Acid Boric, ʒ 2
Magnes. Carbonat., ℥ ss
Menthol, gr., 8
Oleum. Gualtheria, ♏ 10
Acid Carbolic Liq., ♏ 10
Creta. Precip., ℥ 1
Misce: fiat dentifric.

The last prescription will be found useful for patients who cannot endure soap in dentifrice.

In prescribing tooth powders and lotions for habitual use it is mostly necessary to study the taste of the individual patient. Few will constantly use a preparation which is disagreeable to them. The amount of

soap—a most useful ingredient of tooth powder—must be varied, as well as the perfumes or flavouring matters introduced, in accordance with the fancy of the patient.

In treatment of caries, as fully explained in the proper places, antiseptics are called for when dentine in the earliest stage of carious affection is to be left in the depths of the cavity, and when exposure of the pulp with inflammation and its sequels have supervened. Many of the agents useful in these conditions have already been mentioned. Some further account of their properties may now be added and other drugs may be briefly described. Formalin is a 35 to 40% solution of the gas formic aldehyde in water. This is a very powerful germicide. It may be used in conjunction with arsenic to destroy the pulp, or in solution 4 to 20% to sterilise carious surfaces and to disinfect putrid pulp canals. It may be used to a strength ¼ to ½% solution as a mouth wash or gargle in pyorrhœa alveolaris or other severe septic conditions of the mouth.

Iodoform does not destroy micro-organic life but prevents proliferation of bacteria. Its nauseous odour, which is apt to penetrate temporary stoppings, makes it a very unsuitable agent for use in the mouth. Iodol, a similar compound, is free from odour. It is useful as a root dressing.

Peroxide of hydrogen is a powerful non-irritating germicide. It may be used in disinfecting pulp canals, and also in treatment of pyorrhœa.

Eugenol is a form of phenol derived from essential oils of cloves, cinnamon, &c., and is used in place of those oils as a dressing for inflamed pulps.

Guaiacol may be looked upon, practically, as a form of purified creosote. It is used by some operators in preference to carbolic acid or creosote and for similar purposes, as an antiseptic and escharotic.

Iodide of zinc may be used as a mouth wash in septic conditions—10 to 20 grains to an ounce of water.

Thymol being only slightly soluble in water is best used, when needed in full strength, with glycerine, in which a solution of 1 in 200 may be made. It may be employed in treating putrid nerve canals and alveolar abscess, and in conjuction with carbolic acid. It may also be used as a dressing for the gums and as a lotion, as above prescribed, in pyorrhœa alveolaris, and other septic conditions of the mouth.

Many other antiseptics such as *Listerine* and *Sanitas* prepared by reputable manufacturers, are useful and to be relied upon as mouth disinfectants, albeit their exact composition is for commercial reasons kept secret.

Antiseptic agents may be divided into a few groups. Some, like carbolic acid and formalin, used in full strength, combine escharotic properties, and are useful in destroying sloughing tissues, or acting upon the lining of fistulous tracts or foul abscesses. Other agents, like perchloride of mercury, owing to poisonous or irritating qualities, must be used with caution on vascular surfaces. Another group, of which peroxide of hydrogen is a typical example, whilst powerful germincides, are perfectly free from irritating or destructive properties. A third group, including such drugs as iodoform and boracic acid, and the oils of eucalyptus, cloves and winter-green, have but slight destructive power over micro-organic life, but can be depended upon to keep a disinfected surface in an aseptic condition.

Out of the large number of agents having similar and equal powers, most practitioners content themselves with a comparatively small selection, taking care to make themselves thoroughly familiar with the properties and mode of use of those they thus prefer.

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THE END